

**Solution for Site Multihoming in a Real IP Environment**  
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Abstract

This document provides a solution for Site Multihoming of stub networks in a real IP environment. Each user interface in a customer network may have as many global unicast addresses as many service providers it will be connected with. Users can establish multiple connections through different service providers simultaneously. Customer networks can maintain private address space to communicate within its users. Customer networks can provide IP mobility services as well.

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## Table of Contents

<a href="#">1. Introduction.....</a>	<a href="#">2</a>
<a href="#">2. Solution for site multihoming.....</a>	<a href="#">3</a>
<a href="#">2.1. Selection of source address.....</a>	<a href="#">5</a>
<a href="#">2.1.1. The desired approach.....</a>	<a href="#">6</a>
<a href="#">2.2. Multihoming and IP Mobility.....</a>	<a href="#">7</a>
<a href="#">2.2.1. IP Address Stacking.....</a>	<a href="#">8</a>
<a href="#">2.3. Implementation aspects.....</a>	<a href="#">12</a>
<a href="#">2.3.1. Processing of system call 'getsrcaddr'.....</a>	<a href="#">13</a>
<a href="#">2.3.2. Processing of the routine 'gethostbynamewithsrcaddr'.....</a>	<a href="#">14</a>
<a href="#">2.3.3. Changes required in ip_output and ip_forwarding modules.....</a>	<a href="#">16</a>
<a href="#">2.3.4. Processing of protocol input routines and socket IO system calls.....</a>	<a href="#">17</a>
<a href="#">2.4. Multihoming, VPN and load sharing.....</a>	<a href="#">17</a>
<a href="#">3. Security Consideration.....</a>	<a href="#">20</a>
<a href="#">4. IANA Consideration.....</a>	<a href="#">20</a>
<a href="#">5. Normative References.....</a>	<a href="#">20</a>
<a href="#">6. Informative References.....</a>	<a href="#">21</a>
<a href="#">7. Author's Address.....</a>	<a href="#">21</a>

**[1. Introduction](#)**

Based on the definition of "multihoming" as stated in [RFC3582\[1\]](#),

"A "multihomed" site is one with more than one transit provider.  
"Site-multihoming" is the practice of arranging a site to be  
multihomed."

This is a general solution for site multihoming of stub networks in a real IP world irrespective of the framework supported by the service provider network. The solution is applicable to any customer network that receives globally unique IP addresses for all of its nodes and communicates with the rest of the world without the help of NAT[15]. It is applicable to any version of IP, i.e. IPv4, IPv6 or any new generation of IP that may emerge by removing the drawbacks associated with IPv6[7]. Within a provider assigned address space, each customer network will possess as many global unicast address space as many service providers it gets connected with. So, an user interface of a host may have as many global unicast addresses as many service providers it will be connected with.

Users can maintain multiple connections through multiple service providers simultaneously. A customer network can maintain private IP addresses to communicate within its users. Communication using private IP is restricted to private IP space for the sake of privacy. Customer networks can provide IP mobility support as well.

There are many variants of UNIX systems (as well as real time



operating systems) which make use of BSD source code for their implementation of TCP/IP stack. The solution given below highlights the changes required with the BSD release 4.4 source code with the notations used by IPv4. It addresses issues relevant to IPv6 wherever applicable. All other implementations of TCP/IP have to be updated in the similar manner.

In this document the term "default router" will refer to the customer edge (CE) router that communicates with the provider network. Also the term "intermediate routers" will refer to all the routers apart from the CE routers.

## **2. Solution for site multihoming**

[RFC1122](#)[2] made an extensive study related to different aspects of multihoming. Some of the requirements suggested in that document related to UDP and the application layer were avoided for multihomed hosts in a connected network with a single gateway to reach the outside world. This was achieved by the implementation of TCP/IP by making sure that the interface address of an outgoing packet gets selected based on the route to be followed by the destination address. This criterion holds good in a connected environment with a single gateway to reach the outside world. Once more than one gateway comes into play to reach the outside world, either routing table of the entire world has to be brought in or needs some enhancements within the existing system to make the things work.

Whenever a customer network gets service from more than one service provider, the customer network can be viewed as having multiple source-id (user-id) space. Each of these IP domain gets connected to different service providers through different routers. So each interface of customer network may have as many global unicast addresses as many service providers it is connected with. Number of routing entries in the routing table will (roughly) become a multiple of IP domains that it supports. Communication between any two hosts within the customer network will follow the traditional routing mechanism. In order to provide multihoming services it is needed that a host computer always forwards packets to the customer edge router associated to the same IP domain while communicating to someone in the outside world. i.e. if the interface of a host computer H receives an IP address 'addr1' and 'addr2' from two service providers P1 and P2 which are connected through routers R1 and R2 respectively, host H has to forward a packet to R1 while using its IP address as 'addr1' in order to send packets to the outside world. So, host computers as well as the intermediate routers have to use default routing based on the source domain of the source address in the IP header.



In order to achieve this, host computers as well as intermediate routers need to have information related to its IP domain (net address/net mask) and the associated default router for all of its IP domains. They need to have a route entry per IP domain for all of its default routers. These information should be uploaded at the system start up time.

Routing of IP packets (in the `ip_output` module of the hosts and in the `ip_forwarding` module of the intermediate routers) need to be modified in the following manner.

If destination address of a packet falls outside of its IP domains, it has to be forwarded to the default router based on the domain that the source address belongs to.

If destination address of the IP header falls within any one of its IP domains, usual routing mechanism has to be followed.

If customer network maintains private IP domain, communication using private IP has to be restricted within private IP space.

UDP (or RAW) based servers that need to support multiple clients simultaneously need to respond to a client's request with the same source address that the client had specified as the destination address. In order to satisfy this, system needs to introduce two system calls along with the existing system calls (i.e. `read`, `write`, `send`, `sendto`, `recv`, `recvfrom`)

```
ssize_t recvwithdstaddr (int sockfd, char *buf, size_t nbytes,  
    int flags, struct sockaddr *from, socklen_t *fromlen,  
    struct sockaddr *fromcladdr, socklen_t *fromcladdrlen,  
    struct sockaddr *dst, socklen_t *dstlen,  
    struct sockaddr *dstcladdr, socklen_t *dstcladdrlen);
```

'`recvwithdstaddr`' receives data with destination address as specified by the sender. It is similar to '`recvfrom`' with the additional field '`dst`' related to the address of the receiving interface of the host. '`fromcladdr`' and '`dstcladdr`' will hold the values of co-located care-of addresses (see [section 2.2](#)) of source and destination if they happen to be mobile.

```
ssize_t sendwithsrcaddr (int sockfd, char *buf, size_t nbytes,  
    int flags, struct sockaddr *to, socklen_t tolen,  
    struct sockaddr *dstcladdr, socklen_t dstcladdrlen,  
    struct sockaddr *src, socklen_t srclen,  
    struct sockaddr *srccladdr, socklen_t srccladdrlen);
```

'`sendwithsrcaddr`' sends data specifying the source address of the



outgoing interface of the host. It is similar to 'sendto' with additional parameters related to source address. It behaves like 'sendto' if no address is specified for 'src'. 'srccladdr' and 'dstcladdr' will hold the values of co-located care-of addresses of source and destination.

All the UDP based servers that need to support multiple clients simultaneously, need to replace 'sendto' with 'sendwithsrcaddr' and 'recvfrom' with 'recvwithdstaddr'.

It has been expressed in several documents including [RFC4291](#)[3], that a single interface will possess multiple IP addresses in a real IP environment. In these cases, all the UDP servers have to be updated with the system calls 'sendwithsrcaddr' and 'recvwithdstaddr' even if a customer site gets attached to a single gateway to reach the outside world.

The same logic will apply to server applications with RAW sockets. Server applications that are TCP based should work in the usual manner.

## 2.1. Selection of source and destination address

If a source network is connected with 'n' service providers and the destination network is connected with 'm' service providers, there will be a possible 'm\*n' combination of source-destination pairs for connection between source and destination. So, application program needs to select a source and destination address before initiating communication with the destination.

A system call needs to be introduced to get the source address based on the destination address. If application program needs to use the destination address directly, it needs to use this system call.

```
int getsrcaddr(int sockfd, struct in_addr *dst, struct in_addr *src);
```

It returns the number of source addresses that can be used. The addresses will be available from 'src', which is an array of type struct in\_addr. The 'src' addresses will be available in sorted manner. Application program needs to use these source addresses from the top (i.e. the 0th) to establish connection with the destination. 'sockfd' is used to get the 'type of service' assigned. So, an application program needs to set its type of service before using this call.

Client applications need to use 'getsrcaddr' and 'bind' the source address before communicating with their peer.





Users may use name instead of IP address to reach the destination. The usual procedure is to use the system call 'gethostbyname' to resolve the destination address and then to use the same for communication. The destination may also be multihomed. In order to find out the best possible choice to reach the destination, another system call needs to be introduced.

```
struct hostent *gethostbynamewithsrcaddr(int sockfd, const char *name,
                                         int *ndst, struct addr_pair *dst);
```

where 'addr\_pair' is defined as

```
struct addr_pair {
    struct in_addr src;
    struct in_addr dst;
};
```

'gethostbynamewithsrcaddr' takes 'name' and 'sockfd' as input parameters and finds out the best possible route to reach the destination. It returns the pointer to the 'hostent' structure as returned by 'gethostbyname' system call. The parameter 'ndst' gets the number of possible routes to be used and the corresponding source and destination addresses gets assigned to 'dst' in sorted manner. 'sockfd' is used to get the 'type of service' assigned. So, an application program needs to set its type of service before using this call.

Source and destination address is selected based on the measurement of least round trip delay for all possible source-destination pairs by sending echo messages.

#### 2.1.1. The desired approach

In order to transport a packet from one network to another, provider network sets up a LSP. In RSVP[10,11], resource reservation is receiver-initiated. In the Path message, the sending application constructs Path message using RSVP SENDER\_TSPEC and ADSPEC objects. The path properties of ADSPEC object gets modified by the network elements as the Path message moves from sender to receiver. The receiver makes use of SENDER\_TSPEC and ADSPEC objects and forms FLOWSPEC object and sends back to the network element towards the sender. In order to make decision which path an application should select from multiple possible paths due to multihoming, ADSPEC object that was received by the receiver has to be passed back to the sender. For best effort service, path is selected based on widest-shortest path approach, i.e. the path having the maximum effective available bandwidth with minimum NUMBER\_OF\_IS\_HOPS. Effective available bandwidth is calculated as



bandwidth allocated to the customer  
----- \* AVAILABLE\_PATH\_BANDWIDTH  
bandwidth allocated to all the customers

If (Effective available bandwidth > unused bandwidth  
allocated to the customer)  
Effective available bandwidth = unused bandwidth  
allocated to the customer.

For Guaranteed bandwidth[14] and Controlled-Load service[13] path is selected with MINIMUM\_PATH\_LATENCY with minimum NUMBER\_OF\_IS\_HOPS.

When a Path message is sent from a user to the ingress PE router, for best-effort service the PE router sets up a LSP with the egress PE router and stores the path attributes with the ADSPEC objects if no LSP has already been created. The ingress PE router sends the path attributes (with AVAILABLE\_PATH\_BANDWIDTH set as Effective available bandwidth) to the sender. If ingress PE router finds an existing LSP for the destination node, it sends the path attributes associated to the LSP. For Guaranteed bandwidth and controlled load service, sender application needs to send PathTear message for all the paths that are not selected.

A PE router will be in a different address space than the address space of the customer network. As hosts need not be aware of the PE routers, hosts need to send queries to the CE router to get the address of the PE router and store the same in their cache, the way it works with DNS.

Once these features will become effective with RSVP, and MPLS UNI[12], the procedure based on the measurement of least round trip delay will not be required any more.

## **2.2. Multihoming, IP Mobility and Provider Independent addressing**

For a mobile node, its co-located care-of IP address[4] has to be bound to one of the IP addresses supported by the service providers (if mobile node advertises more than one address, the home agent will get confused, also there are other implications). Transport layer must ensure that the 'home address' gets tightly coupled with that particular IP address.

A mobile node in a foreign site will have all the IP addresses supported by the foreign site as well as its "Home Address". As the mobile node will also communicate with the outside world with its "Home Address", user should get a provision to choose its "Home Address" while initiating communication. If mobile node makes use of the address of foreign site for applications that do not need its



"Home Address" (say, accessing a web site) cost of communication will get reduced. This feature is useful when a mobile user is in a foreign site but remains within the same sphere of influence (say an user lives in one city but works in a different city which is in a different sphere of influence and likes to access web during his working hours).

If "Home Address" is selected for communication, the transport layer of the mobile node should use its care-of address as the source address and pass its "Home Address" as an option field in the stack. This is because multihoming expects the source address as the deciding factor for packet forwarding.

The IP address of a node with a provider independent address have to be mapped with one of the global unicast addresses. So for the purpose of multihoming whatever will be applicable to a mobile node will also be applicable to a node with provider independent address.

All the issues that need to be handled for IP mobility, provider independent addressing related to multihoming have been thoroughly discussed in [section 4](#) of the architectural specification[7]. Please go through that section first before going through the rest.

As the destination address may be a PI address, a client application needs to call 'connrmtaddr' after it calls 'bind'. As all the client applications (either TCP/UDP/RAW) needs to call 'getsrcaddr'/'gethostbynamewithsrcaddr', 'bind' and 'connrmtaddr' their pattern will apparently look alike.

### **2.2.1. IP Address Stacking**

IP address stacking in IPv6 is performed with the approach introduced in [section 6.4 of RFC6275](#)[8] with slight modification. [RFC6275](#) describes how to pass "Home Address" as well as co-located care-of address of the destination address if it happen to be mobile. The same approach has been extended to support IP address stacking for the source address and to support IP address stacking for both source address as well as destination address. The "Reserved" space in the type 2 routing header has been split into two parts; an one octet field to address the "Stacking Type" and the rest 3 octets are left as Reserved.

Stacking Type is interpreted as follows:

Stacking Type=0

Source Address: Address of the sender.

Destination Address: co-located care-of address of the receiver.

Address 1: Home Address/PI Address of the receiver.



Hdr Ext Len=2.

So, type 2 routing header for stacking type 0 will be as follows:

```

+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| Next Header | Hdr Ext Len=2 | Routing Type=2|Segments Left=1|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|Stacking Type=0|                Reserved                |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|                                                              |
+                                                              +
|                                                              |
+      Address 1:Home Address/PI Address of the receiver      +
|                                                              |
+                                                              +
|                                                              |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

Stacking Type=1

Source Address: co-located care-of address of the sender.

Destination address: Address of the receiver.

Address 1: Home Address/PI Address of the sender.

Hdr Ext Len=2.

So, type 2 routing header for stacking type 1 will be as follows:

```

+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| Next Header | Hdr Ext Len=2 | Routing Type=2|Segments Left=1|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|Stacking Type=1|                Reserved                |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|                                                              |
+                                                              +
|                                                              |
+      Address 1:Home Address/PI Address of the sender      +
|                                                              |
+                                                              +
|                                                              |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

Stacking Type 2

Source Address: co-located care-of address of the sender.

Destination Address: co-located care-of address of the receiver.

Address 1: Home Address/PI Address of the sender.

Address 2: Home Address/PI Address of the receiver.

Hdr Ext Len=4.

So, type 2 routing header for stacking type 2 will be as follows:





```

+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| Next Header | Hdr Ext Len=4 | Routing Type=2|Segments Left=1|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|Stacking Type=2|                Reserved                |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|
+
|
+      Address 1:Home Address/PI Address of the sender      +
|
+
|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|
+
|
+      Address 2:Home Address/PI Address of the receiver    +
|
+
|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

**Next Header**

8-bit selector. Identifies the type of header immediately following the routing header. Uses the same values as the IPv6 Next Header field [9].

**Hdr Ext Len**

4 (8-bit unsigned integer); length of the routing header in 8-octet units, not including the first 8 octets.

**Routing Type**

2 (8-bit unsigned integer).

**Segments Left**

1 (8-bit unsigned integer).

**Stacking Type**

2 (8-bit unsigned integer).

**Reserved**

24-bit reserved field. The value MUST be initialized to zero by the sender, and MUST be ignored by the receiver.

**Address 1**

Home Address/PI Address of the sender.

**Address 2**



Home Address/PI Address of the receiver.

IP address stacking in IPv4 is performed by introducing new IP option under the option class "Datagram or Network Control", i.e. 0. The option number is 16. The CODE(144) field is followed by one octet field "Stacking Type" followed by two octet reserved space (NULL) as padding followed by the address fields based on the Stacking Type.

Stacking Type is interpreted as follows:

Stacking Type=0

Source Address: Address of the sender.

Destination Address: co-located care-of address of the receiver.

Address 1: Home Address/PI Address of the receiver.

Header Length:7

Format of IP address stacking option with stacking type 0 in the IP header will be as follows:

```

+-+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
| CODE(144)    |Stacking Type=0| Reserved                               |
+-+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
+      Address 1:Home Address/PI Address of the receiver      +
+-+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

```

Stacking Type=1

Source Address: co-located care-of address of the sender.

Destination Address: Address of the receiver.

Address 1: Home Address/PI Address of the sender.

Header Length:7

Format of IP address stacking option with stacking type 1 in the IP header will be as follows:

```

+-+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
| CODE(144)    |Stacking Type=1| Reserved                               |
+-+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
+      Address 1:Home Address/PI Address of the sender      +
+-+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

```

Stacking Type=2

Source Address: co-located care-of address of the sender.

Destination Address: co-located care-of address of the receiver.

Address 1: Home Address/PI Address of the sender.

Address 2: Home Address/PI Address of the receiver.

Header Length:8

Format of IP address stacking option with stacking type 2 in the IP header will be as follows:



```

+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| CODE(144)      |Stacking Type=2| Reserved                        |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
+      Address 1:Home Address/PI Address of the sender      +
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
+      Address 2:Home Address/PI Address of the receiver    +
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

### 2.3. Implementation aspects

Following changes are expected with the source code of BSD.

Introduce `ip_domain` structure and some parameters as follows:

```

struct ip_domain {
    struct in_addr net_addr;
    struct in_addr net_mask;
    struct in_addr def_router;
};
#define MAX_IP_DOMAINS    16
short num_ipdomains;
struct ip_domain *ipdomain[MAX_IP_DOMAINS];

```

If customer network maintains private IP domain (along with the user-id space provided by the service providers) and expects its communication to be confined within its own space, 'def\_router' has to be set as NULL.

Upload IP domain information for all of its IP domains during system start up. These domain information can be uploaded through router advertisement or through DHCP. The domain information should contain the next hop address to reach the corresponding default router as well.

There has to be a provision to upload these information through 'sysctl' to configure them manually.

Three new 'sysctl' routines have to be introduced under the 'ip' node of the MIB tree (i.e. under CTL\_NET, PF\_INET, IPPROTO\_IP) IPCTL\_NUM\_DOMAINS, IPCTL\_DOMAIN and IPCTL\_USE\_HOMEADDR (applicable for mobile node). Both IPCTL\_NUM\_DOMAINS and IPCTL\_USE\_HOMEADDR are of type CTLTYPE\_INT and IPCTL\_DOMAIN is of type CTLTYPE\_NODE. Using 'sysctl' IPCTL\_NUM\_DOMAINS has to be configured first. Configuration of IPCTL\_NUM\_DOMAINS has to populate IPCTL\_NUM\_DOMAIN entries of nodes under IPCTL\_DOMAIN and for each of these nodes three MIB attributes DOMAIN\_NET\_ADDR, DOMAIN\_NET\_MASK and DOMAIN\_DEF\_ROUTER (each of type CTLTYPE\_NODE) has to be allocated.



All the routers as well as hosts that are having interfaces connecting to multiple subnets (see [section 2.4](#)) need to be configured through 'sysctl'.

Mobile users should get provision to change IPCTL\_USE\_HOMEADDR attribute dynamically.

Add a route entry for all the default routers during system start up.

### **2.3.1. Processing of system call 'getsrcaddr'**

Introduce a routine (say 'getendpointaddr') that will find out the round trip delay from a list of source addresses to a list of destination addresses by sending echo messages and return the list of source and destination address pairs in sorted manner based on their round trip delay. The routine should set the type of service field of the echo messages same as that of the application (which can be obtained by calling 'getsockopt' with the socket id 'sockfd' passed as a parameter).

This routine has to be modified once MPLS UNI will support the features stated in [section 2.1.1](#).

System call 'getsrcaddr' has to be processed in the following manner:

```
If destination address of the IP packet falls outside of its
IP domains {
  If user has selected its "Home Address" {
    /*Applicable to IP mobility/PI address*/
    return its "Home Address";
  }
  If destination address is from private address space {
    if the host is having only one interface {
      call 'getendpointaddr' for the destination address
      with all the private addresses assigned to it. get source
      address based on the output of 'getendpointaddr'.
    }
    else {
      for all the default routers {
        use 'rtalloc' to get the next hop address for the
        default router.

        select source address based on the outgoing interface
        'ia', and the private address associated with the default
        router.
      }
      call 'getendpointaddr' for the destination address with
      all the private addresses selected above. get source
```





```
        address based on the output of 'getendpointaddr'.
    }
}
else {
    if the host is having only one interface {
        call 'getendpointaddr' for the destination address
        with all the global unicast addresses assigned to it. get
        source addresses based on the output of 'getendpointaddr'.
    }
    else {
        for all the default routers {
            use 'rtalloc' to get the next hop address for the
            default router.

            select source address based on the outgoing interface
            'ia', and the global unicast address associated
            with the default router.
        }
        call 'getendpointaddr' for the destination address with
        all the global unicast addresses selected above. get source
        address based on the output of 'getendpointaddr'.
    }
}
}
else { /* i.e. destination address is inside its IP domains */
    use 'rtalloc' to get the next hop address for the
    destination address.

    if destination address is a link local address {
        select source address based on the outgoing interface
        and the link local address assigned to it.
    }
    else {
        select source address based on the outgoing interface
        and the domain that the destination address belongs to.
    }
}
```

### **2.3.2. Processing of the routine 'gethostbynamewithsrcaddr'**

System call 'gethostbynamewithsrcaddr' has to be processed in the following manner:

This is an enhancement of the system call 'gethostbyname'. 'gethostbyname' calls three routines that performs host table search, NIS search and DNS search. Once name is resolved, following additions are expected to resolve source-destination pair.



```
If 'hostent' structure contains addresses which are inside its IP
domains {
    if 'hostent' structure contains a private address {
        Assign destination address as a private address
        contained in 'hostent';

        use 'rtalloc' to get the next hop address for the
        destination address.

        select source address based on the outgoing interface
        and the domain that the destination address belongs to.
    }
    else {
        Select a global unicast address contained in 'hostent' for
        destination address.

        use 'rtalloc' to get the next hop address for the
        destination address.

        select source address based on the outgoing interface
        and the domain that the destination address belongs to.
    }
}
else {
    if 'hostent' structure contains private address {
        if host is having only one interface {
            call 'getendpointaddr' with all the private addresses
            returned by 'gethostbyname' as destination addresses
            with all the private addresses assigned to it as host
            addresses and return source and destination addresses
            based on its output.
        }
        else {
            for all the default routers {
                use 'rtalloc' to get the next hop address for the
                default router.

                select source address based on the outgoing interface
                'ia', and the private address associated with the default
                router.
            }
            call 'getendpointaddr' with all the private addresses
            returned by 'gethostbyname' as destination addresses
            with all the selected private addresses above as host
            addresses. get source and destination addresses
            based on the output of 'getendpointaddr'.
        }
    }
}
```



```
else {
    if user has selected its "Home Address" {
        /*Applicable to IP mobility/PI address*/

        Call 'getendpointaddr' with all the addresses returned
        by 'gethostbyname' as destination addresses with the
        "Home Address" and return source and destination
        addresses based on its output.
    }
    if host is having only one interface {
        Call 'getendpointaddr' with all the addresses returned
        by 'gethostbyname' as destination addresses with all of its
        global unicast addresses as source addresses and return
        source and destination addresses based on its output.
    }
    else {
        for all the default routers {
            use 'rtalloc' to get the next hop address for the
            default router.

            select source address based on the outgoing interface
            'ia', and the global unicast address associated
            with the default router.
        }
        call 'getendpointaddr' with all the global unicast
        addresses returned by 'gethostbyname' as destination
        addresses with all the selected global unicast addresses
        as host addresses. get source and destination addresses
        based on the output of 'getendpointaddr'.
    }
}
}
```

### **2.3.3. Changes required in ip\_output and ip\_forwarding modules**

Execute the following steps in the 'ip\_output' routine of the IP stack before it calls 'rtalloc' for route look up.

```
If destination address of the IP packet falls outside of its
IP domains {
    get def router address based on the IP domain
    the source address belongs to.

    use 'rtalloc' to get the next hop address for the def router.

    Forward the packet to the next hop.
}
else { /* i.e. destination address is inside its IP domains */
```



```
    follow the usual procedure to forward packets
}
```

In BSD, the 'ip\_forwarding' routine calls 'ip\_output'; so it should be left as it is.

#### **2.3.4. Processing of protocol input routines and socket IO system calls**

Protocol input routines need to locate the socket/process in the usual manner with the 5 unit tuple (i.e. protocol, source address, source port, destination address, destination port).

When a packet is received by a mobile node (at a foreign site), it can be received in two modes. It can be received directly from the correspondent node with the 'destination address' as the co-located care-of address and its home address in the IP stack (see [section 4.1 of RFC6275\[8\]](#)). In the second mode the packet can be received via the home agent using IP over IP. Once the IP layer receives a packet with IP over IP, it is supposed to strip off the outer header before passing the packet to the protocol input routine. In this case packet will be received by the protocol input routine with destination address as the home address of the mobile node with no information related to its care-of address. So, protocol input routine needs to check whether the destination address of the received packet belongs to any one of its IP domains. If it does not, it needs to find out the co-located care-of address by going through the interface list if it is not already found in the packet received. This information is needed by the TCP input routine while processing a SYN message. It is also needed by the UDP/RAW modules while processing the system call 'recvwithdstaddr'.

While processing the output routines like 'sendwithsrcaddr', 'sendto', UDP/RAW modules needs to check the parameters related to source address, source port, destination address, destination port, care-of address of the source, care-of address of the destination in the protocol control block. Parameters in the PCB should prevail over parameters passed by the system call while forming the IP packet.

#### **2.4. Multihoming, VPN and load sharing**

For a corporate, that maintains multiple offices and communicates within themselves through private address space using VPN, can operate in two ways. It can operate in monolithic mode in which each unit of its office will have a single private address space where as in the second approach, each unit will have multiple private address space each one will be associated with a particular service provider. If CP-PE link fails due to any reason, in case of monolithic mode same sessions can be continued with proper protection mechanism as





described below; where as in the other case existing sessions have to be restarted, but no protection mechanism is required. In both the cases, entire private address space has to be distributed within its different units in a suitable manner.

In monolithic mode, load of outgoing traffic can be shared by segregating private IP domain of each office into number of sub domains through suitable configuration. Let us consider one of its offices gets connected to two providers P1 and P2 and gets address space as 'unicastNetAddr1'/'unicastNetMask1' and 'unicastNetAddr2'/'unicastNetMask2' respectively. It also gets assigned private address space as 'privateDomainNetAddr'/'privateDomainNetMask' from its corporate. For load sharing, it wants to maintain two sub domains with its ID space as 'subDomainNetAddr1'/'subDomainNetMask1' and 'subDomainNetAddr2'/'subDomainNetMask2' respectively. Domain 1 gets associated with the default router CE1 and domain 2 gets associated with CE2. Host computers and intermediate routers will be configured in the following manner:

All hosts of sub domain 1 will have three entries of ip\_domain:

```
1: 'net_addr = 'unicastNetAddr1'
   'net_mask = 'unicastNetMask1'
   'def_router = CE1
2: 'net_addr = 'unicastNetAddr2'
   'net_mask = 'unicastNetMask2'
   'def_router = CE2
3: 'net_addr' = 'privateDomainNetAddr'
   'net_mask' = 'privateDomainNetMask'
   'def_router' = CE1
```

All hosts of sub domain 2 will have three entries of ip\_domain:

```
1: 'net_addr = 'unicastNetAddr1'
   'net_mask = 'unicastNetMask1'
   'def_router = CE1
2: 'net_addr = 'unicastNetAddr2'
   'net_mask = 'unicastNetMask2'
   'def_router = CE2
3: 'net_addr' = 'privateDomainNetAddr'
   'net_mask' = 'privateDomainNetMask'
   'def_router' = CE2
```

All intermediate routers will have four entries of ip\_domain:

```
1: 'net_addr = 'unicastNetAddr1'
   'net_mask = 'unicastNetMask1'
```



```
'def_router' = CE1
2: 'net_addr' = 'unicastNetAddr2'
   'net_mask' = 'unicastNetMask2'
   'def_router' = CE2
3: 'net_addr' = 'subDomainNetAddr1'
   'net_mask' = 'subDomainNetMask1'
   'def_router' = CE1
4: 'net_addr' = 'subDomainNetAddr2'
   'net_mask' = 'subDomainNetMask2'
   'def_router' = CE2
```

If any of the CE-PE link fails, that particular CE needs to forward its outgoing traffic to the other CE whose CE-PE link remains active. This can be achieved through tunneling mechanism or by providing a hot link between the CEs. Forwarding of packets should be restricted to packets with private IP space. CE routers need to communicate within themselves at regular intervals and elect a leader within themselves. The elected leader should get privilege to forward private IP broadcast packets to other sites in order to avoid multiplicity. Broadcast packets that are originated only at the local site needs to be forwarded to the other sites. For a remote site, which is connected with PE routers RPE1 and RPE2, PE router of local site can load share its outgoing traffic by segregating its outgoing traffic with a suitable manner. If any of the link between RPE1 or RPE2 fails, it needs to forward all the traffic to the active link as well.

In case of the second approach, each one of its offices will get multiple private address space. Let us consider one of its offices gets connected to two providers P1 and P2 and gets address space as 'unicastNetAddr1'/'unicastNetMask1' and 'unicastNetAddr2'/'unicastNetMask2' respectively. It also gets assigned private address space as 'privateDomainNetAddr1'/'privateDomainNetMask1' and 'privateDomainNetAddr2'/'privateDomainNetMask2' which will be associated with the CE routers CE1 and CE2 respectively.

All hosts as well as the intermediate routers will have four entries of ip\_domain:

```
1: 'net_addr' = 'unicastNetAddr1'
   'net_mask' = 'unicastNetMask1'
   'def_router' = CE1
2: 'net_addr' = 'unicastNetAddr2'
   'net_mask' = 'unicastNetMask2'
   'def_router' = CE2
3: 'net_addr' = 'privateDomainNetAddr1'
   'net_mask' = 'privateDomainNetMask1'
```



```
'def_router' = CE1
4: 'net_addr' = 'privateDomainNetAddr2'
   'net_mask' = 'privateDomainNetMask2'
   'def_router' = CE2
```

For a remote site, which is connected with PE routers RPE1 and RPE2 and receives private address spaces 'privateAddr1'/'privateMask1' and 'privateAddr2'/'privateMask2' respectively, PE router of local site PE1 have to assign 'privateAddr1'/'privateMask1' for the link PE1-RPE1 and address block 'privateAddr2'/'privateMask2' for the link PE1-RPE2.

### 3. Security Consideration

This document provides a solution for site multihoming of stub networks. It does not introduce any security related issue. All the issues related to separation of locator and identifier that were addressed in [RFC4218](#)[5] are not applicable here but for common security related issues that any site may experience, one needs to consult with the "Site Security Handbook", [RFC2196](#)[6]. For issues related to IP Mobility, [section 5 of RFC5944](#)[4] has to be consulted.

### 4. IANA Consideration

This draft does not request any action from IANA.

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