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Mobile-IPv4 Configuration Option for PPP IPCP

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Abstract

Mobile IP [RFC 2002] defines media-independent procedures by which a Mobile Node can maintain existing transport and application-layer connections despite changing its point-of-attachment to the Internet and without changing its IP address. PPP [RFC 1661] provides a standard method for transporting multi-protocol packets over point-to-point links. As currently specified, Mobile IP Foreign Agents which support Mobile Node connections via PPP can do so only by first assigning unique addresses to those Mobile Nodes, defeating one of the primary advantages of Foreign Agents. This documents corrects this problem by defining the Mobile-IPv4 Configuration Option to the Internet Protocol Control Protocol (IPCP) [RFC 1332]. Using this option, two peers can communicate their support for Mobile IP during the IPCP phase of PPP. Familiarity with Mobile IP [RFC 2002], IPCP [RFC 1332], and PPP [RFC 1661] is assumed.

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1. Introduction

Mobile IP [RFC 2002] defines protocols and procedures by which packets can be routed to a mobile node, regardless of its current point-of-attachment to the Internet, and without changing its IP address. Mobile IP is designed to run over any type of media and any type of data link-layer. However, the interaction between Mobile IP and PPP is currently underspecified and generally results in an inappropriate application of Mobile IP when mobile nodes connect to the Internet via PPP.

This document defines proper interaction between a mobile node [RFC 2002] and a peer through which the mobile node connects to the Internet using PPP. This requires the definition of a new option for IPCP [RFC 1332], named the "Mobile-IPv4" Configuration Option, which is defined in this document. The mobile node and the peer use this option to negotiate the appropriate use of Mobile IP over the PPP link.

The Mobile-IPv4 option defined in this document is intended to work in conjunction with the existing IP-Address option [RFC 1332].

1.1. Specification Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119.

1.2. Terminology

This document uses the following terms as defined in [RFC 2002]:

Mobile Node

A host or router that changes its point-of-attachment from one link to another. A mobile node may change its location without changing its IP address; it may continue to communicate with other Internet nodes at any location using its (permanent) home, IP address, assuming link-layer connectivity is available at its current location.

Home Agent

A router with at least one interface on a mobile node's home link. A home agent intercepts packets destined to a mobile node's home address and tunnels them to the mobile node's care-of address when the mobile node is connected to a foreign link. A mobile node informs its home agent of its current care-of address through an authenticated registration protocol defined by Mobile IP.

Foreign Agent

A router with at least one interface on a mobile node's (current) foreign link. When a mobile node uses a foreign agent's care-of address, the foreign agent detunnels and delivers packets to the mobile node that were tunneled by the mobile node's home agent. A foreign agent might also serve as a default router for packets sent by a registered mobile node.

Peer

The PPP peer of a mobile node. The mobile node's peer might support home agent functionality, foreign agent functionality, both, or neither.

1.3. Problem Statement

In Mobile IP, packets sent to a mobile node's home address are routed first to the mobile node's home agent, a router on the mobile node's home link which intercepts packets sent to the home address. The home agent then tunnels such packets to the mobile node's care-of address, where the packets are extracted from the tunnel and delivered to the mobile node. There are two types of care-of addresses:

Co-located Care-of Address

An address temporarily assigned to a mobile node itself. In this case, the mobile node is the exit-point of the tunnel and decapsulates packets encapsulated for delivery by its home agent. A Co-located Care-of Address may be used by exactly one mobile node at any point in time.

Foreign Agent Care-of Address

An address of a foreign agent that has at least one interface on a mobile node's visited, foreign link. In this case, the foreign agent decapsulates packets that have been tunneled by the home agent and delivers them to the mobile node over the visited link. A Foreign Agent Care-of Address may be used simultaneously by many mobile nodes at any point in time.

In Appendix B, Mobile IP [RFC 2002] currently specifies only the following with respect to PPP:

"The Point-to-Point-Protocol (PPP) [RFC 1661] and its Internet Protocol Control Protocol (IPCP) [RFC 1332], negotiates [sic] the use of IP addresses.

"The mobile node SHOULD first attempt to specify its home address, so that if the mobile node is attaching to its home [link], the unrouted link will function correctly. When the home address is not accepted by the peer, but a transient IP address is dynamically assigned to the mobile node, and the mobile node is capable of supporting a co-located care-of address, the mobile node MAY register that address as a co-located care-of address. When the peer specifies its own IP address, that address MUST NOT be assumed to be a foreign agent care-of address or the IP address of a home agent."

Inspection of this text reveals that there is currently no way for the mobile node to use a foreign agent care-of address, without first being assigned a unique IP address, even if the peer also supports foreign agent functionality. The reason for this can be seen by walking through the IPCP negotiation:

1. A mobile node connects to a peer via PPP and proposes its home address in an IPCP Configure-Request containing the IP-Address option. In this scenario, we assume that the mobile node is connecting to some foreign link.

2. The peer has no way of knowing whether this Configure-Request was received from: (a) a mobile node proposing its home address; or (b) a conventional node proposing some topologically non-routable address. In this case, the peer must (conservatively) send a Configure-Nak of the IP-Address option supplying a topologically appropriate address for use by the node at the other end of the PPP link.

3. The mobile node, in turn, has no way of knowing whether this Configure-Nak was received because the peer is a foreign agent being conservative, or because the peer does not implement Mobile IP at all. Therefore, the mobile node must (conservatively) assume that the peer does not implement Mobile IP and continue the negotiation of an IP address in IPCP, after which point the mobile node can use the assigned address as a co-located care-of address.

Here we observe that, even if the mobile node's peer is a foreign agent and sends an Agent Advertisement to the mobile node after IPCP reaches the Opened state, the mobile node will still have negotiated a routable address in step 3, which it is likely already using as a co-located care-of address. This defeats the purpose of foreign agent care-of addresses, which are designed to be shared by multiple mobile nodes and to eliminate the need to assign a unique address to each mobile node.

1.4. Requirements

The purpose of this document is to specify the behavior of both ends of the PPP link when one or more of the PPP peers supports Mobile IP. Specifically, the design of the option and protocol defined in this document is based upon the following requirements:

1. The option and protocol described in this document must be backwards compatible with conventional nodes and their potential peers which do not implement this option nor any Mobile IP functionality.

2. The option and protocol described in this document must accommodate a variety of scenarios, minimally those provided in the examples of Section 2.6.

3. The option and protocol described in this document must not duplicate any functionality already defined in other IPCP options; specifically, the IP-Address option.

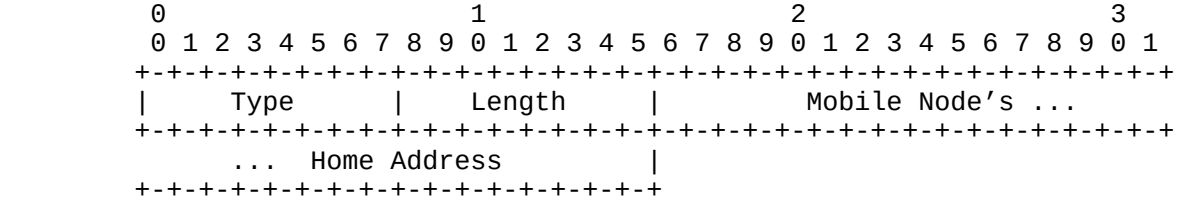
4. A unique address must not be assigned to a mobile node unless absolutely necessary. Specifically, no such address is assigned to a mobile node that connects via PPP to its home link or a mobile node that connects via PPP to a foreign agent (and uses that foreign agent's care-of address).

2. Mobile-IPv4 Configuration Option

This section defines the Mobile-IPv4 Configuration Option and provides several examples of its use.

2.1. Option Format

The Mobile-IPv4 Configuration Option for IPCP is defined as follows:



Type

4 (Mobile-IPv4)

Length

6 (The length of this entire extension in bytes)

Mobile Node's Home Address

In a Configure-Request, the IP home address of the mobile node sending this Configuration Option, otherwise the (unmodified) IP home address of the mobile node when sent in a Configure-Ack or Configure-Reject. Configure-Nak'ing this option is undefined and MUST NOT be sent by implementations complying with this version of the specification. This field MUST NOT be zero.

Default Value

The Mobile-IPv4 Configuration Option defaults to the sending mobile node's home address.

In describing the operation of the Mobile-IPv4 Configuration Option (in conjunction with the IP-Address Configuration Option), we use the following abbreviations:

```
PPP Message Types:
    Request = Configure-Request
     Reject = Configure-Reject
        Ack = Configure-Ack
        Nak = Configure-Nak

IPCP Configuration Options:
      MIPv4 = Mobile-IPv4
         IP = IP-Address

IP addresses:
    a.b.c.d = some non-zero IP address
    w.x.y.z = some non-zero IP address other than a.b.c.d
       home = a mobile node's IP Home address
        coa = an IP Care-Of Address
          0 = the all-zeroes IP address (0.0.0.0)
```

2.2. Overview

The Mobile-IPv4 Configuration Option is designed to be used in conjunction with the IP-Address Configuration Option. For the convenience of implementors, the detailed description in section 2.5 includes all possible combinations of these two options that might be sent by a PPP peer during IPCP. Along with each possibility is a description of how the receiver should interpret the contents as well as a suggested course of action.

2.3. High-Level Requirements for Non-Mobile-Nodes

A node that is not performing mobile node functionality (such as non-Mobile-IP-aware nodes as well as nodes performing only home agent functionality, foreign agent functionality, or both) MUST NOT include a Mobile-IPv4 Configuration Option within any Configure-Request message. As per [RFC 1332], such a node SHOULD send a Configure-Request containing an IP-Address Configuration Option in which the IP-Address field is set to a non-zero IP address that the node has assigned to one of its interfaces. If an explicit IP address has been assigned to the node's PPP interface then this address SHOULD be sent in preference to any of the node's other addresses.

A node MUST NOT send a Configure-Nak containing a Mobile-IPv4 Configuration Option. Doing so is currently "undefined" and might cause interoperability problems when a useful meaning for Configure-Nak is ultimately defined for the Mobile-IPv4 Configuration Option. A node that sends a Configure-Ack containing a Mobile-IPv4 Configuration Option SHOULD send an Agent Advertisement [RFC 2002] immediately upon IPCP for that link entering the Opened state.

2.4. High-Level Requirements for Mobile Nodes

A mobile node SHOULD begin its IPCP negotiation by sending the Configure-Request described in either item #1 or item #4 in Section 2.5. The mobile node MAY begin its negotiation with one of the other numbered items in Section 2.5 under extenuating circumstances.

A mobile node that receives a Configure-Ack containing a Mobile-IPv4 Configuration Option MUST receive an Agent Advertisement, possibly in response to an Agent Solicitation, before sending a Registration Request [RFC 2002] if that mobile node is connecting to a foreign link. This is because the peer might be a foreign agent that enforces a policy which requires a mobile node to register with that foreign agent even if the mobile node is using a co-located care-of address. A mobile node need not wait for such an advertisement if it connects to its home link. See item 7a in section 2.5 for one way in which a mobile node can determine if it has connected to its home link. Another way is by receiving an explicit notification of this fact from its peer, such as receipt of the messages in items 1b, 2c, and 3a in section 2.5.

A mobile node that receives a Configure-Reject containing a Mobile-IPv4 Configuration Option SHOULD fall back to IPCP negotiation using the IP-Address option [RFC 1332]. A mobile node SHOULD begin this negotiation with Request(IP=home) or Request(IP=0), depending on whether or not the mobile node is connecting to its home link, respectively. A mobile node MAY make this determination by inspection of an IP-Address option contained within a Configure-Request sent by its peer. If the prefix of the peer's stated IP-address is equal to the prefix of the mobile node's home address, then the mobile node MAY conclude that it is connecting to its home link. Otherwise, if the mobile node is connecting to a foreign link, then the mobile node SHOULD send Request(IP=0) since its peer might have no means for assigning addresses other than IPCP. This specification therefore updates this behavior as described in [RFC 2002], the latter of which recommends that a mobile node begin IP-Address negotiation with Request(IP=Home) under all circumstances.

A peer that is performing neither home agent nor foreign agent functionality SHOULD send a Reject in response to any Request received from its peer that contains a Mobile-IPv4 Configuration Option.

2.5. Detailed Description

The numbered items below show all possible combinations of Mobile-IPv4 and IP-Address Configuration Options that a mobile node (or a conventional node) might send to its peer. Mobile nodes SHOULD begin

their IPCP negotiation with item #1 or item #4 depending on whether they prefer a co-located or a foreign agent care-of address respectively. The lettered items list the possible legal responses that a peer might send to the mobile node (or conventional node) in response to the numbered Request.

In each case, an interpretation is defined and a suggested course of action is provided. Finally, it is believed that the presentation below has the advantages of conciseness and precision in comparison to an equivalent presentation in "prose form."

1. Request(IP=0,MIPv4=home) means "I prefer a co-located care-of address to a foreign agent care-of address." Peer MUST respond with one of the following:

   a. Nak(IP=coa) means "use coa as your co-located care-of address". Goto 2.
   b. Nak(IP=home) means "you're at home and don't need a care-of address". Goto 3.
   c. Reject(IP=0) means "I cannot assign a co-located care-of address but you're welcome to use me as a foreign agent". Goto 4.
   d. Reject(MIPv4=home) means "I do not implement the Mobile-IPv4 option". If the peer also sent Request(IP=address) and the prefix of the peer's assigned address is equal to that of the mobile node's home address, then goto 6 with a.b.c.d=home; otherwise, goto 5.
   e. Reject(IP=0,MIPv4=home) means "use the default". Goto 7.

   => Ack(IP=0, ...), Nak(MIPv4=any, ...) MUST NOT be sent.

2. Request(IP=coa,MIPv4=home) means "I want to use coa as my co-located care-of address." Peer MUST respond with one of the following:

   a. Ack(IP=coa,MIPv4=home) means "ok, use coa as your co-located care-of address; be sure to wait for an advertisement." Opened.
   b. Nak(IP=alternate-coa) means "no, use alternate-coa as your co-located care-of address". Goto 2.
   c. Nak(IP=home) means "you're at home and don't need a co-located care-of address". Goto 3.
   d. Reject(IP=coa) means "coa is not a useful value for a co-located care-of address on this link and I cannot assign a useful one (or I will not negotiate the IP-Address option) -- you may use me as a foreign agent". Goto 4.

e. Reject(MIPv4=home) means "I do not implement the Mobile-IPv4 option". If the peer also sent Request(IP=address) and the prefix of the peer's address is equal to that of the mobile node's home address, then goto 6 with a.b.c.d=home; otherwise, goto 5.
f. Reject(IP=coa,MIPv4=home) means "use the default". Goto 7.

=> Nak(MIPv4=any, ...) MUST NOT be sent.

3. Request(IP=home,MIPv4=home) means "I think I'm at home but if I'm wrong then I prefer a co-located care-of address to a foreign agent care-of address." Peer MUST respond with one of the following:

a. Ack(IP=home,MIPv4=home) means "yes, you're at home". Opened.
b. Nak(IP=coa) means "you're not at home, use coa as your co-located care-of address". Goto 2.
c. Reject(IP=home) means "you're not at home and I cannot assign a co-located care-of address (or I will not negotiate the IP-Address option) -- you may use me as a foreign agent". Goto 4.
d. Reject(MIPv4=home) means "I do not implement the Mobile-IPv4 option". If the peer also sent Request(IP=address) and the prefix of the peer's address is equal to that of the mobile node's home address, then goto 6 with a.b.c.d=home; otherwise, goto 5.
e. Reject(IP=home,MIPv4=home) means "use the default". Goto 7.

=> Nak(MIPv4=any, ...) MUST NOT be sent.

4. Request(MIPv4=home) means "I want to run Mobile IP over this link and I don't want a co-located care-of address." Peer MUST respond with one of the following:

a. Ack(MIPv4=home) means "ok, wait for an advertisement to figure out where you are." Opened.
b. Reject(MIPv4=home) means "I do not implement the Mobile-IPv4 option". If the peer also sent Request(IP=address) and the prefix of the peer's address is equal to that of the mobile node's home address, then goto 6 with a.b.c.d=home; otherwise, goto 5.

=> Nak(MIPv4=any, ...) MUST NOT be sent.

5. Request(IP=0) means "Please assign an address/co-located-care-of-address". Peer MUST respond with one of the following:

a. Nak(IP=a.b.c.d) means "use a.b.c.d as your address/co-located-care-of-address". Goto 6.
b. Reject(IP=0) means "I cannot assign an address (for the Mobile Node to use as a co-located-care-of-address), or I do not implement the IP-Address option". Goto 7.

=> Ack(IP=0) MUST NOT be sent and historically means "I don't know your address either". Opened. An implementation MUST NOT use 0 as its IP address upon receiving Ack(IP=0) but MAY use some other, non-zero, interface address for packets sent on its PPP interface.

6. Request(IP=a.b.c.d) means "I want to use a.b.c.d as my address/home-address/co-located-care-of-address". Peer MUST respond with one of the following:

   a. Ack(IP=a.b.c.d) means "ok, a.b.c.d is your address/home-address/co-located-care-of-address". Opened.
   b. Nak(IP=w.x.y.z) means "no, use w.x.y.z as your address/home-address/co-located-care-of-address". Goto 6.
   c. Reject(IP=a.b.c.d) means "a.b.c.d is a bad address to use, but I cannot give you a good one" or "I do not implement the IP-Address option". Goto 7.

7. Request() means "I want to use the default". Peer MUST respond with one of the following:

   a. Ack() means "ok, use the default". Opened.

      In this case the mobile node will use the "default" values of the IP-Address option (no address configured by IPCP) and the Mobile-IPv4 option (the mobile node's IP home address). The mobile node SHOULD send Agent Solicitations to see if there are any agents present on the current link. (Note that the current "link" might also include a shared medium if the mobile node's PPP peer is a bridge.) If an agent is present and the mobile node receives an Agent Advertisement, then the mobile node employs its move-detection algorithm(s) and registers accordingly.

      In any case, if the mobile node's peer supplied an IP-Address option containing a non-zero value within an IPCP Configure-Request, the mobile node MAY use this address to determine whether or not it is connected to its home link. This can be accomplished by comparing the stated IP address with the mobile node's home address under the prefix-length associated with the home link. If the mobile node is connected to its home link then it SHOULD de-register with its home agent.

Otherwise, the mobile node MAY attempt to obtain a topologically routable address through any of its supported means (e.g., DHCP, manual configuration, etc.) for use as a co-located care-of address. If the mobile node is successful in obtaining such an address then it SHOULD register this address with its home agent.

=> Nak(IP=0) MUST NOT be sent. Goto 6.

=> Nak() MUST NOT be sent.

=> Reject() MUST NOT be sent.

2.6. Example Scenarios

This section illustrates the use of the option and protocol as defined in the previous sections. In the examples which follow, a Configure-Request sent by a mobile node and the response generated by the peer are shown on the same line. The number and letter to the left of each request/response refer to the numbered and lettered items in Section 2.5.

A. A mobile node prefers a co-located care-of address and the peer is a foreign agent that is capable of assigning such an address:

(1)(a) Request(IP=0,MIPv4=Home) / Nak(IP=coa)
(2)(a) Request(IP=coa,MIPv4=Home) / Ack(IP=coa,MIPv4=Home)

- Mobile node waits to receive an Agent Advertisement.
- If (Advertisement has R-bit set) then
  Mobile node registers using co-located care-of address via the foreign agent;
  else
  Mobile node registers using co-located care-of address directly with its home agent.

B. A mobile node prefers a co-located care-of address and the peer is a foreign agent that cannot assign a co-located care-of address (e.g., it has no pool of addresses from which to allocate for the purpose of assignment):

(1)(c) Request(IP=0,MIPv4=Home) / Reject(IP=0)
(4)(a) Request(MIPv4=Home) / Ack(MIPv4=Home)

- IPCP completes.
- Mobile node waits to receive an Agent Advertisement.
- Mobile node registers using the peer’s foreign agent care-of address with its home agent.

C. A mobile node prefers a co-located care-of address and the peer determines that the mobile node's home address is such that the mobile node is connecting to its home link:

(1)(b) Request(IP=0,MIPv4=Home) / Nak(IP=Home)
(3)(a) Request(IP=Home,MIPv4=Home) / Ack(IP=Home,MIPv4=Home)

- IPCP completes.
- Mobile node de-registers with its home agent.

D. A mobile node prefers a foreign agent care-of address and the peer is a foreign agent which finds this state of affairs satisfactory:

(4)(a) Request(MIPv4=Home) / Ack(MIPv4=Home)

- IPCP completes.
- Mobile node waits to receive an Agent Advertisement.
- Mobile node registers using the peer's foreign agent care-of or de-registers at home, depending on the values in the Agent Advertisement.

E. A mobile node prefers a co-located care-of address and the peer does not implement the Mobile-IPv4 Configuration Option. The peer is, however, capable of assigning dynamic addresses:

(1)(d) Request(IP=0,MIPv4=Home) / Reject(MIPv4=Home)
(5)(a) Request(IP=0) / Nak(IP=a.b.c.d)
(6)(a) Request(IP=a.b.c.d) / Ack(IP=a.b.c.d)

- IPCP completes.
- Mobile node registers using a.b.c.d as a co-located care-of address with its home agent.

F. A mobile node prefers a co-located care-of address and the peer does not implement the Mobile-IPv4 Configuration Option. The peer is not capable of assigning dynamic addresses:

(1)(e) Request(IP=0,MIPv4=Home) / Reject(IP=0,MIPv4=Home)
(7)(a) Request() / Ack()

- IPCP completes.
- Mobile node sends an Agent Solicitation and/or attempts to obtain a co-located care-of address via means outside IPCP (e.g., DHCP or manual configuration), or it gives up.

3. Additional Requirements

3.1. Other IPCP Options

A mobile node MUST NOT include the deprecated IP-Addresses option in any Configure-Request that contains a Mobile-IPv4 option, an IP-Address option, or both.

Conversely, the mobile node MAY include an IP-Compression-Protocol option and any other options that do not involve the negotiation of IP addresses.

If a mobile node and a foreign agent or a home agent agree in IPCP to use Van Jacobson Header Compression [RFC 1144], then the mobile node MUST NOT set the 'V' bit in its ensuing Mobile IP Registration Request [RFC 2002]. If the PPP peer entities are utilizing VJ header compression there is no gain for the mobile ip entities to do so, and requesting this option is likely to cause confusion.

3.2. Move Detection

Mobile nodes that connect via PPP MUST correctly implement PPP's IPCP, since movement by the mobile node will likely change its PPP peer. Specifically, mobile nodes MUST be prepared to renegotiate IPCP at any time, including, the renegotiation of the IP-Address Configuration Option and the Mobile-IPv4 Configuration Option described in this document. As per [RFC 1661], a mobile node in the Opened state MUST renegotiate IPCP upon receiving an IPCP Configure-Request from its peer.

Also note that certain wireless links can employ handoff and proxying mechanisms that would not necessarily require bringing down a PPP link but would indeed require a mobile node to register with a new foreign agent. Therefore, mobile nodes which connect to an agent via PPP MUST employ their move detection algorithms (see section 2.4.2 in [RFC 2002]) and register whenever they detect a change in connectivity.

Specifically, a mobile node that fails to receive an Agent Advertisement within the Lifetime advertised by its current foreign agent, MUST assume that it has lost contact with that foreign agent (see Section 2.4.2.1, [RFC 2002]). If, in the mean time, the mobile node has received Agent Advertisements from another foreign agent, the mobile node SHOULD immediately register with that foreign agent upon timing out with its current foreign agent.

Likewise, a mobile node that implements move detection based upon the Prefix-Length Extension MUST compare the prefix of any advertising agents with that of its current foreign agent (see Section 2.4.2.2, [RFC 2002]). If such a mobile node receives an Agent Advertisement from a foreign agent specifying a different prefix than that of its current foreign agent, then the mobile node that employs this method of move detection MUST register with that new foreign agent.

A mobile node MAY treat PPP link-establishment as a sufficient reason to proceed with a new Mobile IP registration. Section 2 defines the circumstances under which mobile nodes MUST wait for an Agent Advertisement before registering. Accordingly, foreign agents and home agents SHOULD send an Agent Advertisement over a PPP link immediately after IPCP for that link enters the Opened state.

4. Security Considerations

This document introduces no known security threats over and above those facing any node on the Internet that either connects via PPP or implements Mobile IP or both. Specifically, service providers should use cryptographically strong authentication (e.g., CHAP [RFC 1994]) to prevent theft-of-service. Additionally, users requiring confidentiality should use PPP link encryption [RFC 1968], IP-layer encryption [RFC 1827], or application-layer encryption, depending upon their individual requirements. Finally, Mobile IP authentication [RFC 2002] protects against trivial denial-of-service attacks that could otherwise be waged against a mobile node and its home agent.

5. References

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6. Acknowledgments

The design of this protocol and option were inspired by an earlier submission by B. Patel and C. Perkins, then of IBM, in a now expired internet draft. Also, some of William Simpson's text was copied verbatim from [RFC 1661] in order to ensure consistency of terminology and specification. The same goes for some of Charlie Perkins' definitions, and other relavent text, from [RFC 2002].

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