                 Microsoft Vendor-specific RADIUS Attributes

Status of this Memo

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Abstract

   This document describes the set of Microsoft vendor-specific RADIUS
   attributes.  These attributes are designed to support Microsoft
   proprietary dial-up protocols and/or provide support for features
   which is not provided by the standard RADIUS attribute set [3].  It
   is expected that this memo will be updated whenever Microsoft defines
   a new vendor-specific attribute, since its primary purpose is to
   provide an open, easily accessible reference for third-parties
   wishing to interoperate with Microsoft products.

1.  Specification of Requirements

   In this document, the key words "MAY", "MUST, "MUST NOT", "optional",
   "recommended", "SHOULD", and "SHOULD NOT" are to be interpreted as
   described in [2].

2.  Attributes

   The following sections describe sub-attributes which may be
   transmitted in one or more RADIUS attributes of type Vendor-Specific
   [3].  More than one sub-attribute MAY be transmitted in a single
   Vendor-Specific Attribute; if this is done, the sub-attributes SHOULD
   be packed as a sequence of Vendor-Type/Vendor-Length/Value triples
   following the inital Type, Length and Vendor-ID fields.  The Length
   field of the Vendor-Specific Attribute MUST be set equal to the sum
   of the Vendor-Length fields of the sub-attributes contained in the
   Vendor-Specific Attribute, plus six.  The Vendor-ID field of the
   Vendor-Specific Attribute(s) MUST be set to decimal 311 (Microsoft).

2.1.  Attributes for Support of MS-CHAP Version 1

2.1.1.  Introduction

   Microsoft created Microsoft Challenge-Handshake Authentication
   Protocol (MS-CHAP) [4] to authenticate remote Windows workstations,
   providing the functionality to which LAN-based users are accustomed.
   Where possible, MS-CHAP is consistent with standard CHAP [5], and the
   differences are easily modularized.  Briefly, the differences between
   MS-CHAP and standard CHAP are:

       * MS-CHAP is enabled by negotiating CHAP Algorithm 0x80 in LCP
         option 3, Authentication Protocol.

       * The MS-CHAP Response packet is in a format designed for
         compatibility with Microsoft Windows NT 3.5, 3.51 and 4.0,
         Microsoft Windows95, and Microsoft LAN Manager 2.x networking
         products.  The MS-CHAP format does not require the authenticator
         to store a clear-text or reversibly encrypted password.

       * MS-CHAP provides an authenticator-controlled authentication
         retry mechanism.

       * MS-CHAP provides an authenticator-controlled password changing
         mechanism.

       * MS-CHAP defines an extended  set of reason-for-failure codes,
         returned in the Failure packet Message field.

   The attributes defined in this section reflect these differences.

2.1.2.  MS-CHAP-Challenge

   Description

       This Attribute contains the challenge sent by a NAS to a Microsoft
       Challenge-Handshake Authentication Protocol (MS-CHAP) user.  It
       MAY be used in both Access-Request and Access-Challenge packets.

   A summary of the MS-CHAP-Challenge Attribute format is shown below.
   The fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type  | Vendor-Length |             String...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
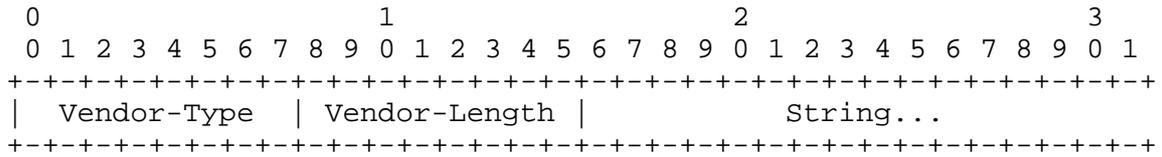
Vendor-Type
   11 for MS-CHAP-Challenge.

Vendor-Length
   > 2

String
   The String field contains the MS-CHAP challenge.

2.1.3.  MS-CHAP-Response

Description

   This Attribute contains the response value provided by a PPP
   Microsoft Challenge-Handshake Authentication Protocol (MS-CHAP)
   user in response to the challenge.  It is only used in Access-
   Request packets.

   A summary of the MS-CHAP-Response Attribute format is shown below.
   The fields are transmitted from left to right.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Vendor-Type   | Vendor-Length |     Ident     |     Flags     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          LM-Response                          
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                            LM-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                            LM-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                            LM-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                            LM-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                            LM-Response(cont)                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          NT-Response
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                            NT-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                            NT-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                            NT-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                            NT-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                            NT-Response (cont)                     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
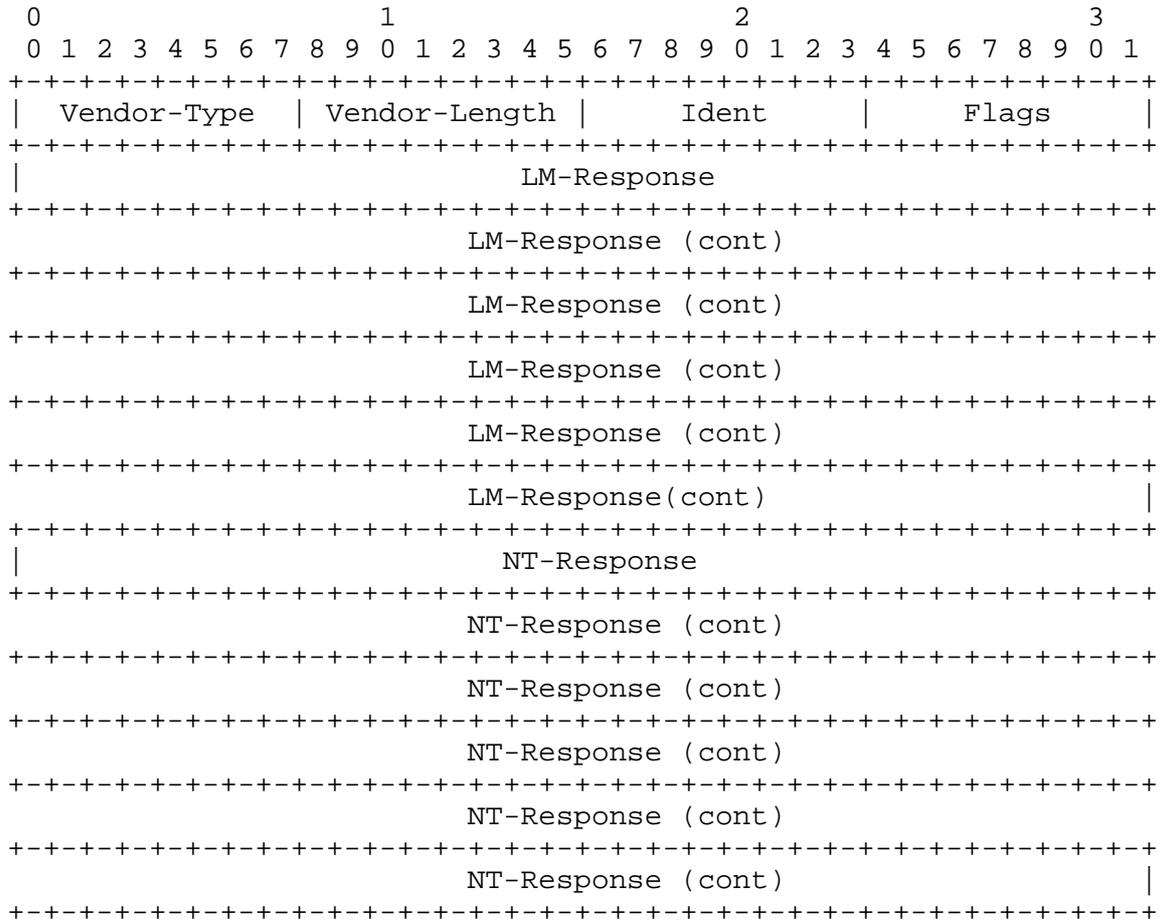
   Vendor-Type
      1 for MS-CHAP-Response.

   Vendor-Length
      52

   Ident
      Identical to the PPP CHAP Identifier.

   Flags
      The Flags field is one octet in length.  If the Flags field is one
      (0x01), the NT-Response field is to be used in preference to the
      LM-Response field for authentication.  The LM-Response field MAY
      still be used (if non-empty), but the NT-Response SHOULD be tried
      first.  If it is zero, the NT-Response field MUST be ignored and
      the LM-Response field used.

   LM-Response
      The LM-Response field is 24 octets in length and holds an encoded
      function of the password and the received challenge.  If this
      field is empty, it SHOULD be zero-filled.

   NT-Response

      The NT-Response field is 24 octets in length and holds an encoded
      function of the password and the received challenge.  If this
      field is empty, it SHOULD be zero-filled.

2.1.4.  MS-CHAP-Domain

   Description

      The MS-CHAP-Domain Attribute indicates the Windows NT domain in
      which the user was authenticated.  It MAY be included in both
      Access-Accept and Accounting-Request packets.

   A summary of the MS-CHAP-Domain Attribute format is given below.  The
   fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Vendor-Type  | Vendor-Length |     Ident     |    String...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   Vendor-Type
      10 for MS-CHAP-Domain.

   Vendor-Length
      > 3

   Ident
      The Ident field is one octet and aids in matching requests and
      replies.

   String
      This  field contains the name in ASCII of the Windows NT domain in
      which the user was authenticated.

2.1.5.  MS-CHAP-Error

   Description

      The MS-CHAP-Error Attribute contains error data related to the
      preceding MS-CHAP exchange.  This Attribute may be used in both
      MS-CHAP-V1 and MS-CHAP-V2 (see below) exchanges.  It is only used
      in Access-Reject packets.

   A summary of the MS-CHAP-Error Attribute format is given below.  The
   fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Vendor-Type  | Vendor-Length |     Ident     |    String...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
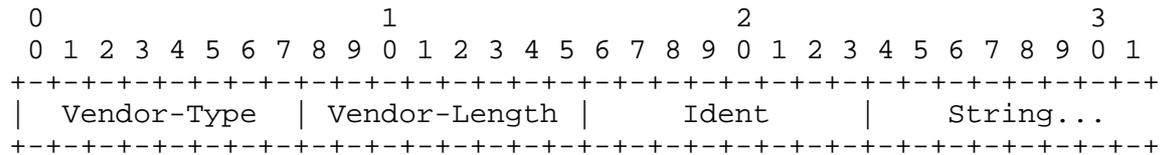
   Vendor-Type
      2 for MS-CHAP-Error.

   Vendor-Length
      > 3

   Ident
      The Ident field is one octet and aids in matching requests and
      replies.

   String
      This field contains specially formatted ASCII text, which is
      interpreted by the authenticating peer.

2.1.6.  MS-CHAP-CPW-1

   Description

      This Attribute allows the user to change their password if it has
      expired.  This Attribute is only used in Access-Request packets, and
      should only be included if an MS-CHAP-Error attribute was included in
      the immediately preceding Access-Reject packet, the String field of
      the MS-CHAP-Error attribute indicated that the user password had
      expired, and the MS-CHAP version is less than 2.

   A summary of the MS-CHAP-CPW-1  Attribute format is shown below.  The
   fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type   | Vendor-Length |      Code      |     Ident     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       LM-Old-Password
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     LM-Old-Password (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     LM-Old-Password (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     LM-Old-Password (cont)                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       LM-New-Password
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     LM-New-Password (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     LM-New-Password (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     LM-New-Password (cont)                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       NT-Old-Password
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     NT-Old-Password (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     NT-Old-Password (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     NT-Old-Password (cont)                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       NT-New-Password
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     NT-New-Password (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     NT-New-Password (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     NT-New-Password (cont)                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     New-LM-Password-Length     |             Flags             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
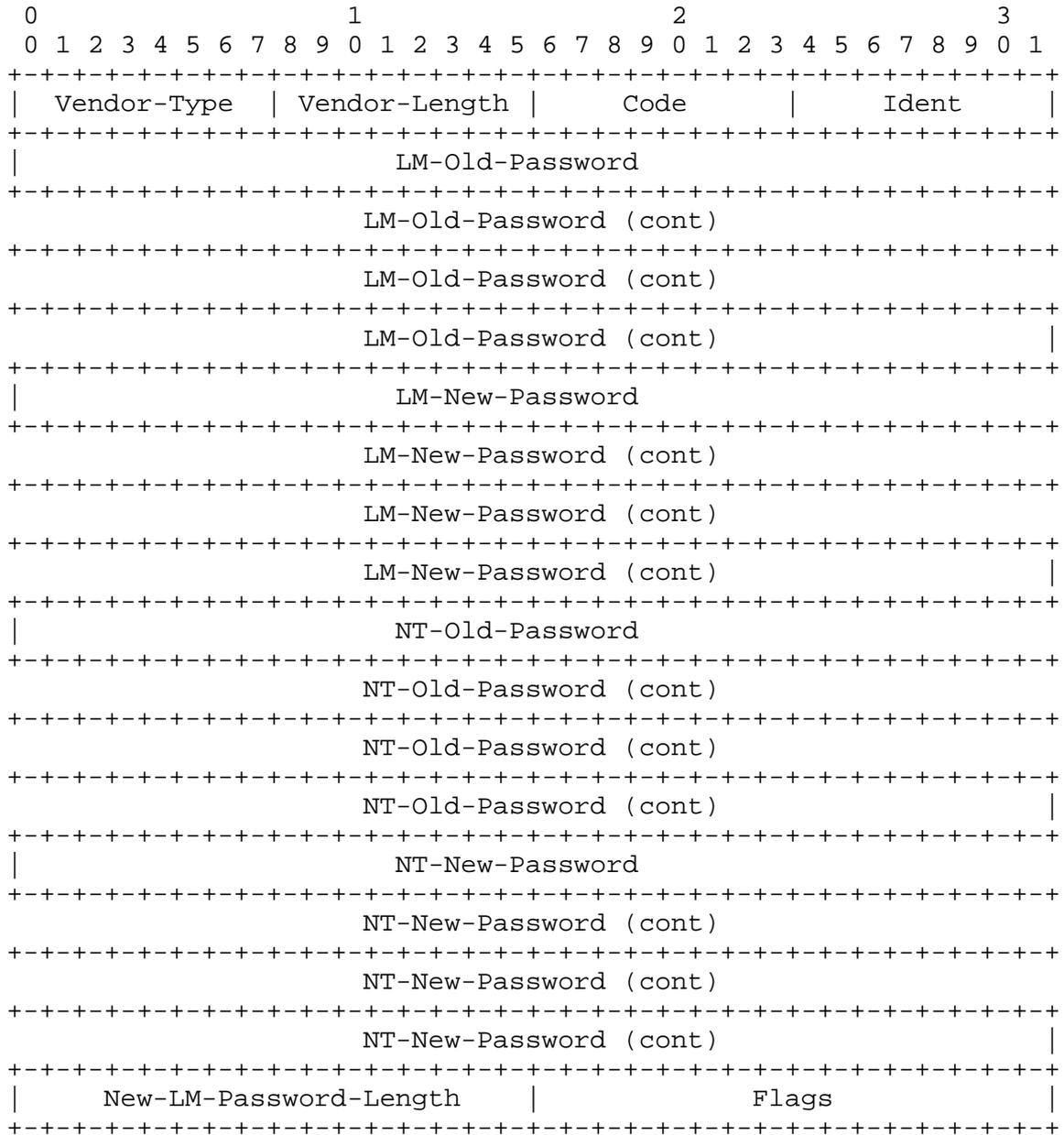
Vendor-Type
   3 for MS-CHAP-PW-1

Vendor-Length
   72

Code
   The Code field is one octet in length.  Its value is always 5.

Ident
   The  Ident  field  is  one octet and aids in matching requests and
   replies.

LM-Old-Password
   The LM-Old-Password field is 16 octets in length.  It contains the
   encrypted Lan Manager hash of the old password.

LM-New-Password
   The LM-New-Password field is 16 octets in length.  It contains the
   encrypted Lan Manager hash of the new password.

NT-Old-Password
   The NT-Old-Password field is 16 octets in length.  It contains the
   encrypted Lan Manager hash of the old password.

NT-New-Password
   The NT-New-Password field is 16 octets in length.  It contains the
   encrypted Lan Manager hash of the new password.

New-LM-Password-Length
   The New-LM-Password-Length field is two octets in length and
   contains the length in octets of the new LAN Manager-compatible
   password.

Flags
   The Flags field is two octets in length.  If the least significant
   bit  of  the  Flags  field is one, this indicates that the NT-New-
   Password and NT-Old-Password fields are valid and SHOULD be  used.
   Otherwise,  the LM-New-Password and LM-Old-Password fields MUST be
   used.

2.1.7.  MS-CHAP-CPW-2

Description

   This Attribute allows the user to change their password if it has
   expired.  This Attribute is only used in Access-Request packets,
   and should only be included if an MS-CHAP-Error attribute was
   included in the immediately preceding Access-Reject packet, the
   String field of the MS-CHAP-Error attribute indicated that the
   user password had expired, and the MS-CHAP version is equal to 2.

A summary of the MS-CHAP-CPW-2  Attribute format is shown below.  The
fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type  | Vendor-Length |     Code      |    Ident      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Old-NT-Hash
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Old-NT-Hash (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Old-NT-Hash (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Old-NT-Hash (cont)                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Old-LM-Hash
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Old-LM-Hash(cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Old-LM-Hash(cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Old-LM-Hash(cont)                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         LM-Response
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        LM-Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        LM-Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        LM-Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        LM-Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        LM-Response (cont)                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          NT-Response
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-++-+-+-+-+-+-+-+-+-+-+-+-+-+
                        NT-Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+--++-+-+-+-+-+-+-+-+-+-+-+-+
                        NT-Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        NT-Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        NT-Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        NT-Response (cont)                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              Flags            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
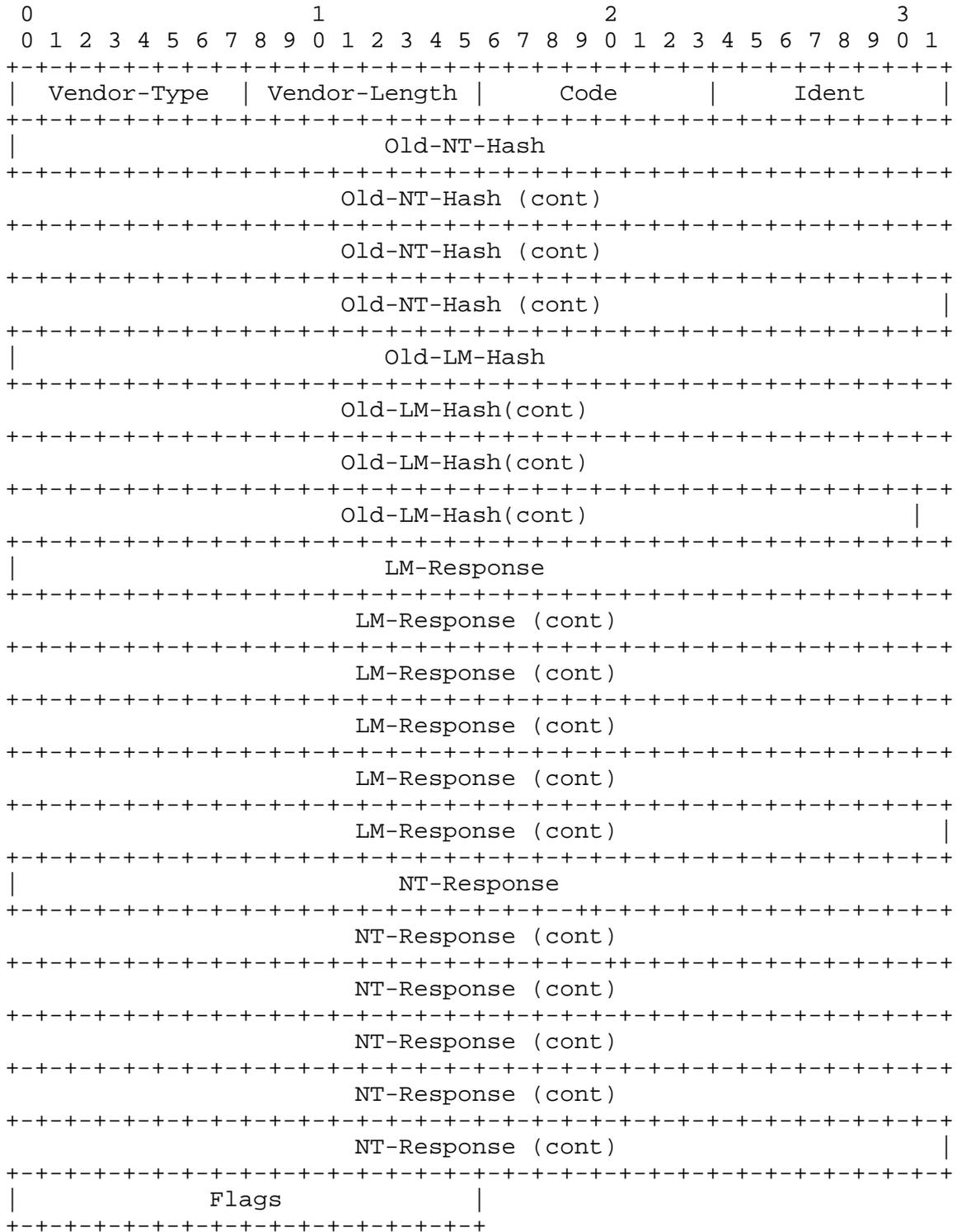
   Vendor-Type
      4 for MS-CHAP-PW-2

   Vendor-Length
      86

   Code
      6

   Ident
      The Ident field is one octet and aids in matching requests and
      replies.  The value of this field MUST be identical to that in the
      Ident field in all instances of the MS-CHAP-LM-Enc-PW, MS-CHAP-NT-
      Enc-PW and MS-CHAP-PW-2 attributes contained in a single Access-
      Request packet.

   Old-NT-Hash
      The Old-NT-Hash field is 16 octets in length.  It contains the old
      Windows NT password hash encrypted with the new Windows NT
      password hash.

   Old-LM-Hash
      The Old-LM-Hash field is 16 octets in length.  It contains the old
      Lan Manager password hash encrypted with the new Windows NT
      password hash.

   LM-Response
      The LM-Response field is 24 octets in length and holds an encoded
      function of the password and the received challenge.  If this
      field is empty, it SHOULD be zero-filled.

   NT-Response
      The NT-Response field is 24 octets in length and holds an encoded
      function of the password and the received challenge.  If this
      field is empty, it SHOULD be zero-filled.

   Flags
      The Flags field is two octets in length.  If the least significant
      bit (bit 0) of this field is one, the NT-Response field is to be
      used in preference to the LM-Response field for authentication.
      The LM-Response field MAY still be used (if present), but the NT-
      Response SHOULD be tried first.  If least significant bit of the
      field is zero, the NT-Response field MUST be ignored and the LM-
      Response field used instead.  If bit 1 of the Flags field is one,
      the Old-LM-Hash field is valid and SHOULD be used.  If this bit is
      set, at least one instance of the MS-CHAP-LM-Enc-PW attribute MUST
      be included in the packet.

2.1.8.  MS-CHAP-LM-Enc-PW

   Description

      This Attribute contains the new Windows NT password encrypted with
      the old LAN Manager password hash.  The encrypted Windows NT
      password is 516 octets in length; since this is longer than the
      maximum lengtth of a RADIUS attribute, the password must be split
      into several attibutes for transmission.  A 2 octet sequence
      number is included in the attribute to help preserve ordering of
      the password fragments.

      This Attribute is only used in Access-Request packets, in
      conjunction with the MS-CHAP-CPW-2 attribute.  It should only be
      included if an MS-CHAP-Error attribute was included in the
      immediately preceding Access-Reject packet, the String field of
      the MS-CHAP-Error attribute indicated that the user password had
      expired, and the MS-CHAP version is 2 or greater.

   A summary of the MS-CHAP-LM-Enc-PW Attribute format is shown below.
   The fields are transmitted from left to right.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  Vendor-Type  | Vendor-Length |      Code     |     Ident     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |        Sequence-Number        |            String ...
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
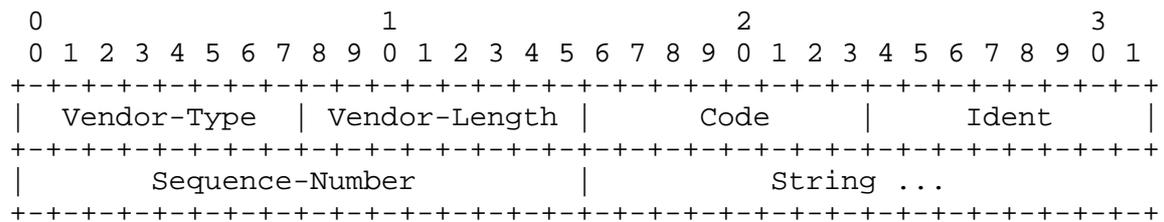
   Vendor-Type
      5 for MS-CHAP-LM-Enc-PW

   Vendor-Length
      > 6

   Code 6.  Code is the same as for the MS-CHAP-PW-2 attribute.

   Ident
      The Ident field is one octet and aids in matching requests and
      replies.  The value of this field MUST be identical in all
      instances of the MS-CHAP-LM-Enc-PW, MS-CHAP-NT-Enc-PW and MS-
      CHAP-PW-2 attributes which are present in the same Access-Request
      packet.

Sequence-Number
   The Sequence-Number field is two octets in length and indicates
   which "chunk" of the encrypted password is contained in the
   following String field.

String The String field contains a portion of the encrypted password.

## 2.2.  MS-CHAP-NT-Enc-PW

Description

   This Attribute contains the new Windows NT password encrypted with
   the old Windows NT password hash.  The encrypted Windows NT
   password is 516 octets in length; since this is longer than the
   maximum lengtth of a RADIUS attribute, the password must be split
   into several attibutes for transmission.  A 2 octet sequence
   number is included in the attribute to help preserve ordering of
   the password fragments.

   This Attribute is only used in Access-Request packets, in conjunc-
   tion with the MS-CHAP-CPW-2 and MS-CHAP2-CPW attributes.  It
   should only be included if an MS-CHAP-Error attribute was included
   in the immediately preceding Access-Reject packet, the String
   field of the MS-CHAP-Error attribute indicated that the user
   password had expired, and the MS-CHAP version is 2 or greater.

A summary of the MS-CHAP-NT-Enc-PW Attribute format is shown below.
The fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Vendor-Type   | Vendor-Length |      Code      |     Ident     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Sequence-Number         |            String ...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
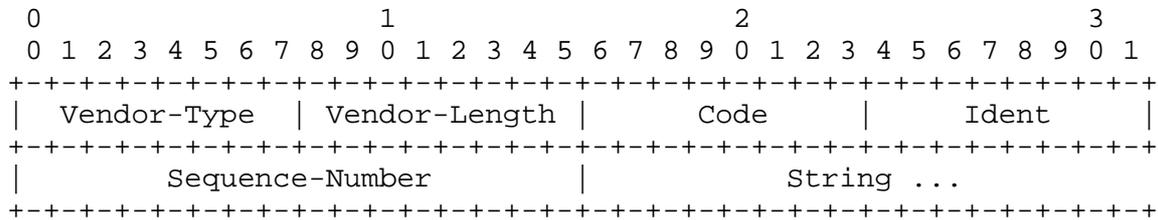
Vendor-Type
   6 for MS-CHAP-NT-Enc-PW

Vendor-Length
   > 6

Code
   6.  Code is the same as for the MS-CHAP-PW-2 attribute.

Ident
   The Ident field is one octet and aids in matching requests and
   replies.  The value of this field MUST be identical in all
   instances of the MS-CHAP-LM-Enc-PW, MS-CHAP-NT-Enc-PW and MS-
   CHAP-PW-2 attributes which are present in the same Access-Request
   packet.

Sequence-Number
   The Sequence-Number field is two octets in length and indicates
   which "chunk" of the encrypted password is contained in the
   following String field.

String
   The String field contains a portion of the encrypted password.

2.3.  Attributes for Support of MS-CHAP Version 2

2.3.1.  Introduction

This section describes RADIUS attributes supporting version two of
Microsoft's PPP CHAP dialect (MS-CHAP-V2) [14].  MS-CHAP-V2 is
similar to, but incompatible with, MS-CHAP version one (MS-CHAP-V1)
[4].  Certain protocol fields have been deleted or reused but with
different semantics.  Where possible, MS-CHAP-V2 is consistent with
both MS-CHAP-V1 and standard CHAP [1].  Briefly, the differences
between MS-CHAP-V2 and MS-CHAP-V1 are:

   * MS-CHAP-V2 is enabled by negotiating CHAP Algorithm 0x81 in LCP
     option 3, Authentication Protocol.

   * MS-CHAP-V2 provides mutual authentication between peers by
     piggybacking a peer challenge on the Response packet and an
     authenticator response on the Success packet.

   * The calculation of the "Windows NT compatible challenge
     response" sub-field in the Response packet has been changed to
     include the peer challenge and the user name.

   * In MS-CHAP-V1, the "LAN Manager compatible challenge response"
     sub-field was always sent in the Response packet.  This field
     has been replaced in MS-CHAP-V2 by the Peer-Challenge field.

   * The format of the Message field in the Failure packet has been
     changed.

   * The Change Password (version 1) and Change Password (version 2)
     packets are no longer supported. They have been replaced with a
     single Change-Password packet.

   The attributes defined in this section reflect these differences.

2.3.2.  MS-CHAP2-Response

   Description

      This Attribute contains the response value provided by an MS-
      CHAP-V2 peer in response to the challenge.  It is only used in
      Access-Request packets.

      A summary of the MS-CHAP2-Response Attribute format is shown below.
      The fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type   | Vendor-Length |     Ident     |     Flags     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Peer-Challenge
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     Peer-Challenge (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     Peer-Challenge (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                     Peer-Challenge (cont)                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Reserved
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       Reserved (cont)                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Response
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       Response (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       Response (cont)                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
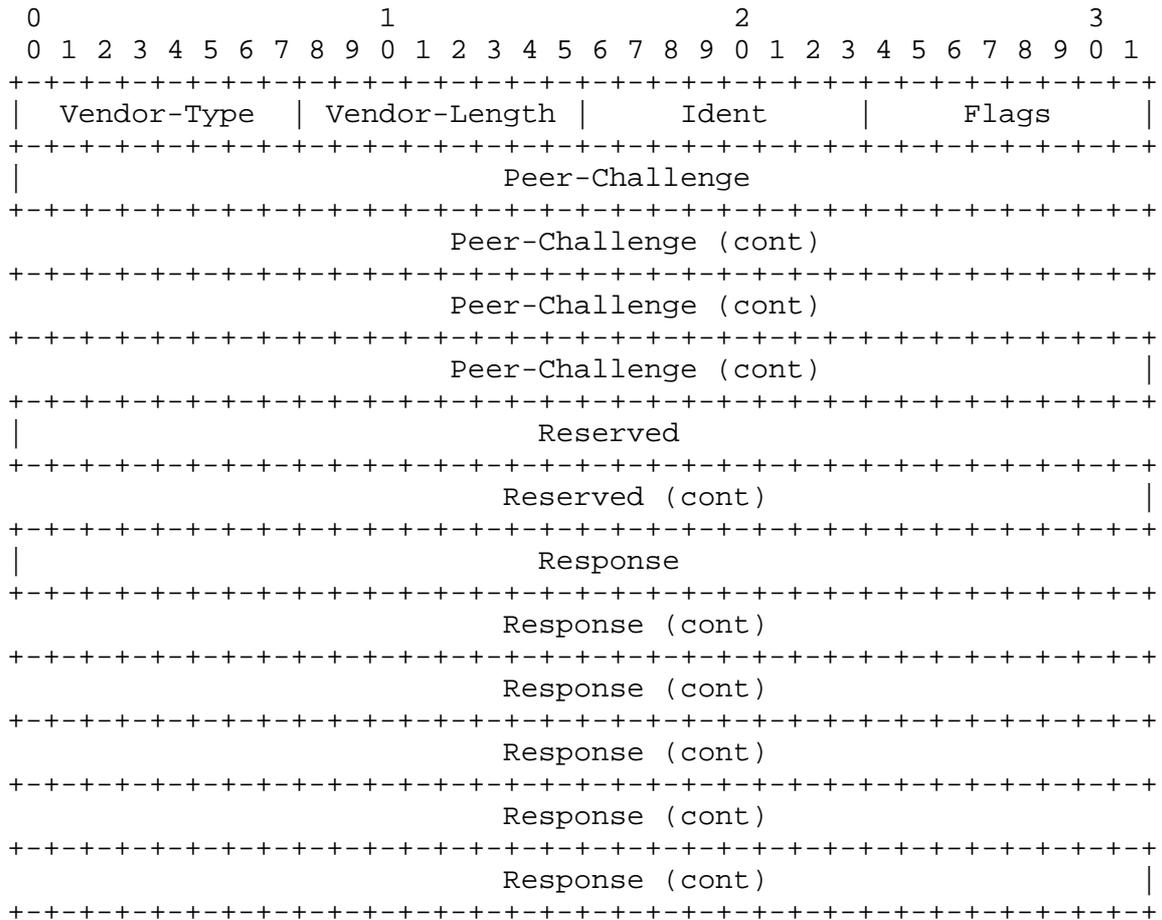
   Vendor-Type
      25 for MS-CHAP2-Response.

   Vendor-Length
      52

   Ident
      Identical to the PPP MS-CHAP v2 Identifier.

   Flags
      The Flags field is one octet in length.  It is reserved for future
      use and MUST be zero.

   Peer-Challenge
      The Peer-Challenge field is a 16-octet random number.

   Reserved
      This field is reserved for future use and MUST be zero.

   Response
      The Response field is 24 octets in length and holds an encoded
      function of the password, the Peer-Challenge field and the
      received challenge.

2.3.3.  MS-CHAP2-Success

   Description

      This Attribute contains a 42-octet authenticator response string.
      This string MUST be included in the Message field of the MS-CHAP-
      V2 Success packet sent from the NAS to the peer.  This Attribute
      is only used in Access-Accept packets.

   A summary of the MS-CHAP2-Success Attribute format is shown below.
   The fields are transmitted from left to right.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Vendor-Type  | Vendor-Length |    Ident      |   String...
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
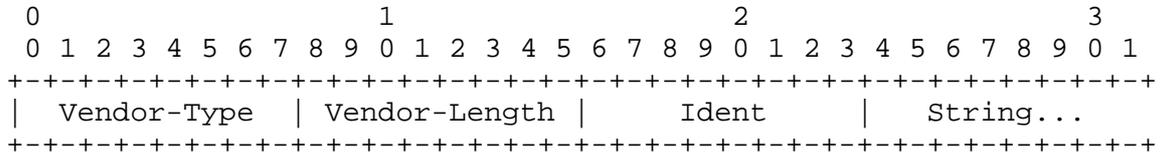
   Vendor-Type
      26 for MS-CHAP2-Success.

   Vendor-Length
      45

   Ident
      Identical to the PPP MS-CHAP v2 Identifier.

   String
      The 42-octet authenticator string (see above).

2.3.4.  MS-CHAP2-CPW

   Description

      This Attribute allows the user to change their password if it has
      expired.  This Attribute is only used in conjunction with the MS-
      CHAP-NT-Enc-PW attribute in Access-Request packets, and should
      only be included if an MS-CHAP-Error attribute was included in the
      immediately preceding Access-Reject packet, the String field of
      the MS-CHAP-Error attribute indicated that the user password had
      expired, and the MS-CHAP version is equal to 3.

   A summary of the MS-CHAP-CPW-2 Attribute format is shown below.   The
   fields are transmitted from left to right.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Vendor-Type   | Vendor-Length |      Code     |     Ident     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                        Encrypted-Hash
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                         Encrypted-Hash (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                         Encrypted-Hash (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                         Encrypted-Hash (cont)                     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                         Peer-Challenge
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                         Peer-Challenge (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                         Peer-Challenge (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                         Peer-Challenge (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                         Peer-Challenge (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                         Peer-Challenge (cont)                     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                          NT-Response
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+--++-+-+-+-+-+-+-+-+-+-+-+-+
                          NT-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+--++-+-+-+-+-+-+-+-+-+-+-+-+
                          NT-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                          NT-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                          NT-Response (cont)
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                          NT-Response (cont)                       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |            Flags              |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
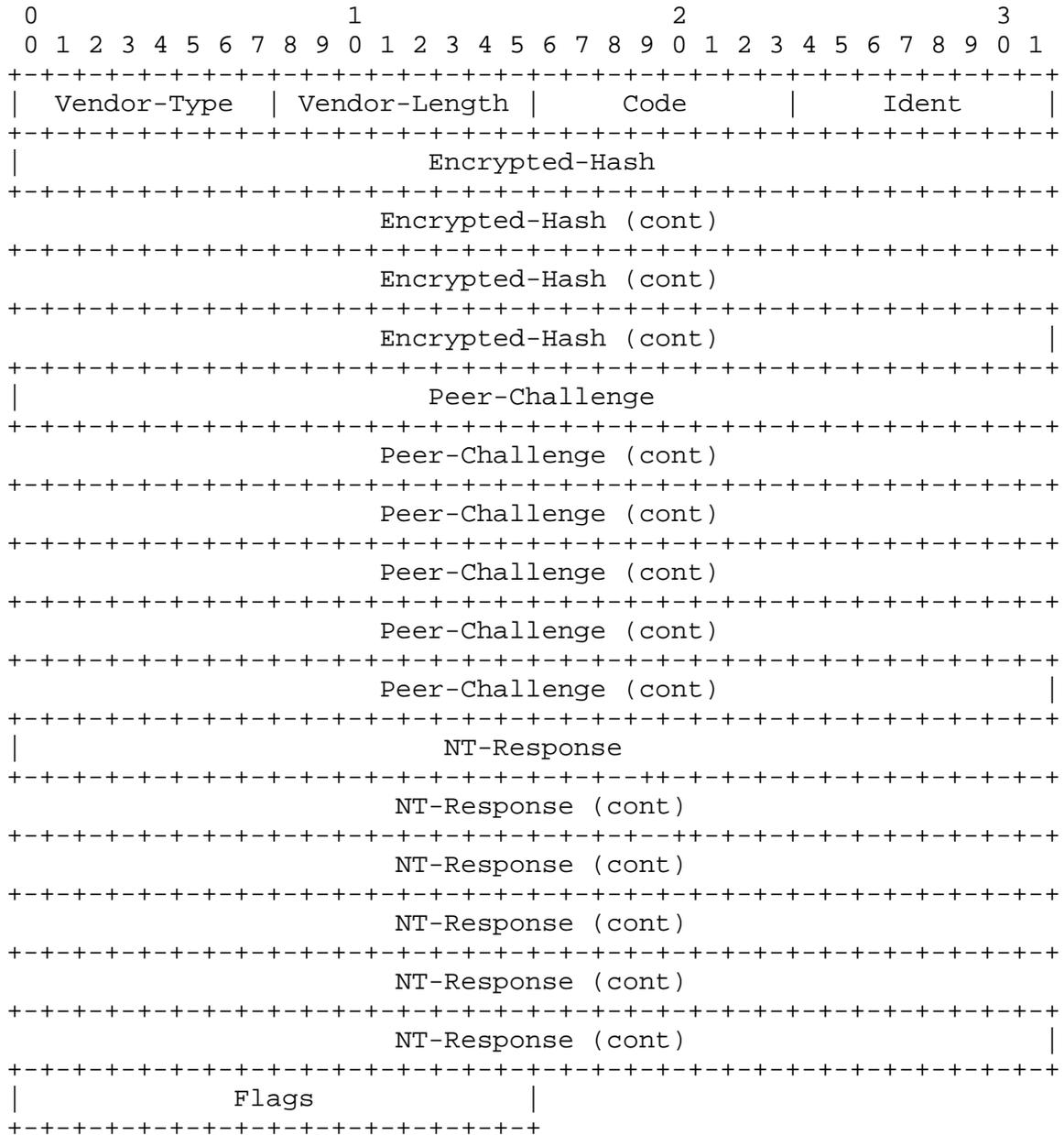
Vendor-Type
   27 for MS-CHAP2-PW

Vendor-Length
   70

Code
   7

Ident
     The Ident field is one octet and aids in matching requests and
     replies.  The value of this field MUST be identical to that in the
     Ident field in all instances of the MS-CHAP-NT-Enc-PW contained in
     the Access-Request packet.

Encrypted-Hash
     The Encrypted-Hash field is 16 octets in length.  It contains the
     old Windows NT password hash encrypted with the new Windows NT
     password hash.

NT-Response
     The NT-Response field is 24 octets in length and holds an encoded
     function of the new password, the Peer-Challenge field and the
     received challenge.

Flags
     The Flags field is two octets in length.  This field is reserved
     for future use and MUST be zero.

## 2.4.  Attributes for MPPE Support

   This section describes a set of Attributes designed to support the
   use of Microsoft Point-to-Point Encryption (MPPE) [6] in dial-up
   networks.  MPPE is a means of representing Point to Point Protocol
   (PPP) [7] packets in a encrypted form.  MPPE uses the RSA RC4 [8]
   algorithm for encryption.  The length of the session key to be used
   for initializing encryption tables can be negotiated; MPPE currently
   supports 40 bit and 128 bit session keys.  MPPE is negotiated within
   option 18 in the PPP Compression Control Protocol (CCP)[9], [10].

### 2.4.1.  MS-CHAP-MPPE-Keys

   Description

     The MS-CHAP-MPPE-Keys Attribute contains two session keys for use
     by the Microsoft Point-to-Point Encryption Protocol (MPPE).  This
     Attribute is only included in Access-Accept packets.

   A summary of the MS-CHAP-MPPE-Keys Attribute format is given below.
   The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type  | Vendor-Length |             Keys
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Keys (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Keys (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Keys (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Keys (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Keys (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Keys (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        Keys (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
          Keys (cont)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Vendor-Type
   12 for MS-CHAP-MPPE-Keys.

Vendor-Length
   34

Keys
   The Keys field consists of two logical sub-fields: the LM-Key and
   the NT-Key.  The LM-Key is eight octets in length and contains the
   first eight bytes of the output of the function LmPasswordHash(P,
   This hash is constructed as follows: let the plain-text password
   be represented by P.

   The NT-Key sub-field is sixteen octets in length and contains the
   first sixteen octets of the hashed Windows NT password.  The
   format of the plaintext Keys field is illustrated in the following
   diagram:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             LM-Key
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                          LM-Key (cont)                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             NT-Key
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                          NT-Key (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                          NT-Key (cont)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                          NT-Key (cont)                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Padding
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                         Padding (cont)                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   The Keys field MUST be encrypted by the RADIUS server using the
   same method defined for the User-Password Attribute [3].  Padding
   is required because the method referenced above requires the field
   to be encrypted to be a multiple of sixteen octets in length.

   Implementation Note
        This attribute should only be returned in response to an
        Access-Request packet containing MS-CHAP attributes.

2.4.2.  MS-MPPE-Send-Key

   Description

      The MS-MPPE-Send-Key Attribute contains a session key for use by
      the Microsoft Point-to-Point Encryption Protocol (MPPE).  As the
      name implies, this key is intended for encrypting packets sent
      from the NAS to the remote host.  This Attribute is only included
      in Access-Accept packets.

   A summary of the MS-MPPE-Send-Key Attribute format is given below.
   The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type   | Vendor-Length |              Salt
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                        String...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
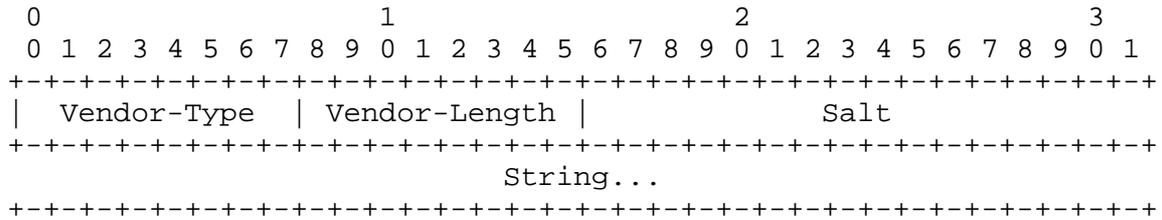
Vendor-Type
   16 for MS-MPPE-Send-Key.

Vendor-Length
   > 4

Salt
   The Salt field is two octets in length and is used to ensure the
   uniqueness of the keys used to encrypt each of the encrypted
   attributes occurring in a given Access-Accept packet.  The most
   significant bit (leftmost) of the Salt field MUST be set (1).  The
   contents of each Salt field in a given Access-Accept packet MUST
   be unique.

String
   The plaintext String field consists of three logical sub-fields:
   the Key-Length and Key sub-fields (both of which are required),
   and the optional Padding sub-field.  The Key-Length sub-field is
   one octet in length and contains the length of the unencrypted Key
   sub-field.  The Key sub-field contains the actual encryption key.
   If the combined length (in octets) of the unencrypted Key-Length
   and Key sub-fields is not an even multiple of 16, then the Padding
   sub-field MUST be present.  If it is present, the length of the
   Padding sub-field is variable, between 1 and 15 octets.  The
   String field MUST be encrypted as follows, prior to transmission:

      Construct a plaintext version of the String field by concate-
      nating the Key-Length and Key sub-fields.  If necessary, pad
      the resulting string until its length (in octets) is an even
      multiple of 16.  It is recommended that zero octets (0x00) be
      used for padding.  Call this plaintext P.

      Call the shared secret S, the pseudo-random 128-bit Request
      Authenticator (from the corresponding Access-Request packet) R,
      and the contents of the Salt field A.  Break P into 16 octet
      chunks $p(1)$, $p(2)...p(i)$, where $i = len(P)/16$.  Call the
      ciphertext blocks $c(1)$, $c(2)...c(i)$ and the final ciphertext C.
      Intermediate values $b(1)$, $b(2)...c(i)$ are required.  Encryption
      is performed in the following manner ('+' indicates
      concatenation):

```
b(1) = MD5(S + R + A)    c(1) = p(1) xor b(1)   C = c(1)
b(2) = MD5(S + c(1))     c(2) = p(2) xor b(2)   C = C + c(2)
           .                        .
           .                        .
           .                        .
b(i) = MD5(S + c(i-1))   c(i) = p(i) xor b(i)   C = C + c(i)
```

The resulting encrypted String field will contain
c(1)+c(2)+...+c(i).

On receipt, the process is reversed to yield the plaintext String.

Implementation Notes
    It is possible that the length of the key returned may be larger
    than needed for the encryption scheme in use.  In this case, the
    RADIUS client is responsible for performing any necessary
    truncation.

    This attribute MAY be used to pass a key from an external (e.g.,
    EAP [15]) server to the RADIUS server.  In this case, it may be
    impossible for the external server to correctly encrypt the key,
    since the RADIUS shared secret might be unavailable.  The external
    server SHOULD, however, return the attribute as defined above; the
    Salt field SHOULD be zero-filled and padding of the String field
    SHOULD be done.  When the RADIUS server receives the attribute
    from the external server, it MUST correctly set the Salt field and
    encrypt the String field before transmitting it to the RADIUS
    client.  If the channel used to communicate the MS-MPPE-Send-Key
    attribute is not secure from eavesdropping, the attribute MUST be
    cryptographically protected.

2.4.3.  MS-MPPE-Recv-Key

Description

    The MS-MPPE-Recv-Key Attribute contains a session key for use by
    the Microsoft Point-to-Point Encryption Protocol (MPPE).  As the
    name implies, this key is intended for encrypting packets received
    by the NAS from the remote host.  This Attribute is only included
    in Access-Accept packets.

A summary of the MS-MPPE-Recv-Key Attribute format is given below.
The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Vendor-Type  | Vendor-Length |               Salt
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                             String...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
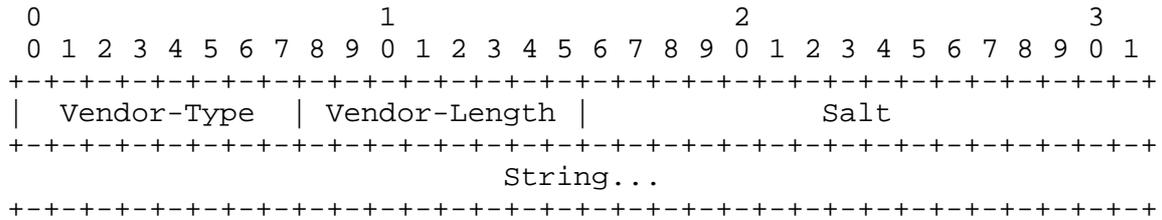
Vendor-Type
   17 for MS-MPPE-Recv-Key.

Vendor-Length
   > 4

Salt
   The Salt field is two octets in length and is used to ensure the
   uniqueness of the keys used to encrypt each of the encrypted
   attributes occurring in a given Access-Accept packet.  The most
   significant bit (leftmost) of the Salt field MUST be set (1).  The
   contents of each Salt field in a given Access-Accept packet MUST
   be unique.

String
   The plaintext String field consists of three logical sub-fields:
   the Key-Length and Key sub-fields (both of which are required),
   and the optional Padding sub-field.  The Key-Length sub-field is
   one octet in length and contains the length of the unencrypted Key
   sub-field.  The Key sub-field contains the actual encryption key.
   If the combined length (in octets) of the unencrypted Key-Length
   and Key sub-fields is not an even multiple of 16, then the Padding
   sub-field MUST be present.  If it is present, the length of the
   Padding sub-field is variable, between 1 and 15 octets.  The
   String field MUST be encrypted as follows, prior to transmission:

      Construct a plaintext version of the String field by
      concatenating the Key-Length and Key sub-fields.  If necessary,
      pad the resulting string until its length (in octets) is an
      even multiple of 16.  It is recommended that zero octets (0x00)
      be used for padding.  Call this plaintext P.

      Call the shared secret S, the pseudo-random 128-bit Request
      Authenticator (from the corresponding Access-Request packet) R,
      and the contents of the Salt field A.  Break P into 16 octet
      chunks $p(1), p(2)...p(i)$, where $i = len(P)/16$.  Call the
      ciphertext blocks $c(1), c(2)...c(i)$ and the final ciphertext C.
      Intermediate values $b(1), b(2)...c(i)$ are required.  Encryption
      is performed in the following manner ('+' indicates
      concatenation):

```
        b(1) = MD5(S + R + A)     c(1) = p(1) xor b(1)   C = c(1)
        b(2) = MD5(S + c(1))      c(2) = p(2) xor b(2)   C = C + c(2)
                    .                       .
                    .                       .
                    .                       .
        b(i) = MD5(S + c(i-1))   c(i) = p(i) xor b(i)   C = C + c(i)
```

        The resulting encrypted String field will contain
        c(1)+c(2)+...+c(i).

     On receipt, the process is reversed to yield the plaintext String.

   Implementation Notes
      It is possible that the length of the key returned may be larger
      than needed for the encryption scheme in use.  In this case, the
      RADIUS client is responsible for performing any necessary
      truncation.

      This attribute MAY be used to pass a key from an external (e.g.,
      EAP [15]) server to the RADIUS server.  In this case, it may be
      impossible for the external server to correctly encrypt the key,
      since the RADIUS shared secret might be unavailable.  The external
      server SHOULD, however, return the attribute as defined above; the
      Salt field SHOULD be zero-filled and padding of the String field
      SHOULD be done.  When the RADIUS server receives the attribute
      from the external server, it MUST correctly set the Salt field and
      encrypt the String field before transmitting it to the RADIUS
      client.  If the channel used to communicate the MS-MPPE-Recv-Key
      attribute is not secure from eavesdropping, the attribute MUST be
      cryptographically protected.

2.4.4.  MS-MPPE-Encryption-Policy

   Description

      The MS-MPPE-Encryption-Policy Attribute may be used to signify
      whether the use of encryption is allowed or required.  If the
      Policy field is equal to 1 (Encryption-Allowed), any or none of
      the encryption types specified in the MS-MPPE-Encryption-Types
      Attribute MAY be used.  If the Policy field is equal to 2
      (Encryption-Required), any of the encryption types specified in
      the MS-MPPE-Encryption-Types Attribute MAY be used, but at least
      one MUST be used.

   A summary of the MS-MPPE-Encryption-Policy Attribute format is given
   below.  The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type   | Vendor-Length |            Policy
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
         Policy (cont)          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
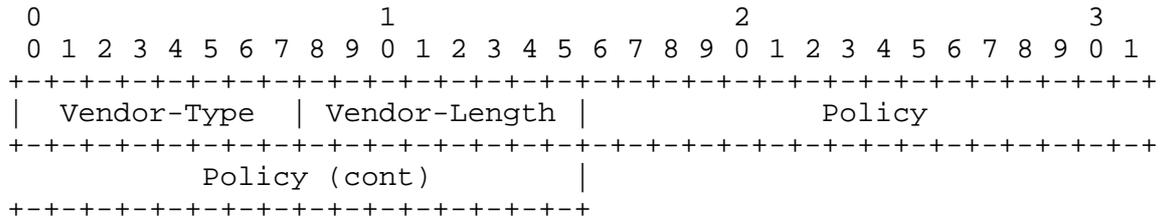
Vendor-Type
   7 for MS-MPPE-Encryption-Policy.

Vendor-Length
   6

Policy
   The Policy field is 4 octets in length.  Defined values are:

       1       Encryption-Allowed 2      Encryption-Required

2.4.5.   MS-MPPE-Encryption-Types

Description

   The MS-MPPE-Encryption-Types Attribute is used to signify the
   types of encryption available for use with MPPE.  It is a four
   octet integer that is interpreted as a string of bits.

A summary of the MS-MPPE-Encryption-Policy Attribute format is given
below.  The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type   | Vendor-Length |            Types
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
         Types (cont)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
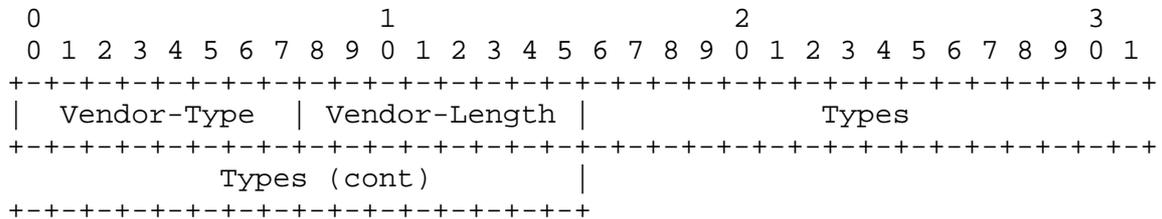
Vendor-Type
   8 for MS-MPPE-Encryption-Types.

Vendor-Length
   6

Policy
   The Types field is 4 octets in length.  The following diagram
   illustrates the Types field.

```
       3                   2                   1
       1 0 9 8 7 6 5 4 3 2 1 0 9 8 7 6 5 4 3 2 1 0 9 8 7 6 5 4 3 2 1 0
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
      |                                                       |S|L| |
      +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
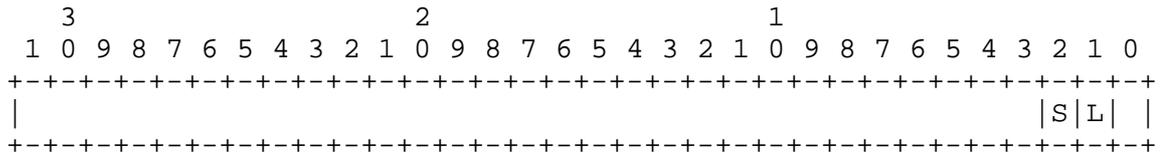
   If the L bit is set, RC4[5] encryption using a 40-bit key is
   allowed.  If the S bit is set, RC4 encryption using a 128-bit key
   is allowed.  If both the L and S bits are set, then either 40- or
   128-bit keys may be used with the RC4 algorithm.

2.5.  Attributes for BAP Support

   This section describes a set of vendor-specific RADIUS attributes
   designed to support the dynamic control of bandwidth allocation in
   multilink PPP [11].  Attributes are defined that specify whether use
   of the PPP Bandwidth Allocation Protocol (BAP) [12] is allowed or
   required on incoming calls, the level of line capacity (expressed as
   a percentage) below which utilization must fall before a link is
   eligible to be dropped, and the length of time (in seconds) that a
   link must be under-utilized before it is dropped.

2.5.1.  MS-BAP-Usage

   Description

      This Attribute describes whether the use of BAP is allowed,
      disallowed or required on new multilink calls.  It MAY be used in
      Access-Accept packets.

   A summary of the MS-BAP-Usage Attribute format is shown below.  The
   fields are transmitted from left to right.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Vendor-Type  | Vendor-Length |            Value
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
            Value (cont)          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
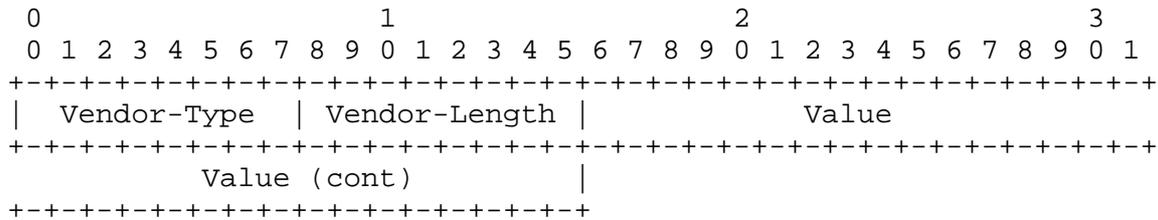
   Vendor-Type
      13 for MS-BAP-Usage.

   Vendor-Length
      6

Value
    The Value field is four octets.

        0        BAP usage not allowed
        1        BAP usage allowed
        2        BAP usage required

2.5.2.  MS-Link-Utilization-Threshold

    Description

        This Attribute represents the percentage of available bandwidth
        utilization below which the link must fall before the link is
        eligible for termination.  Permissible values for the MS-Link-
        Utilization-Threshold Attribute are in the range 1-100, inclusive.
        It is only used in Access-Accept packets.

    A summary of the MS-Link-Utilization-Threshold Attribute format is
    shown below.  The fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type   | Vendor-Length |           Value
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
         Value (cont)          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
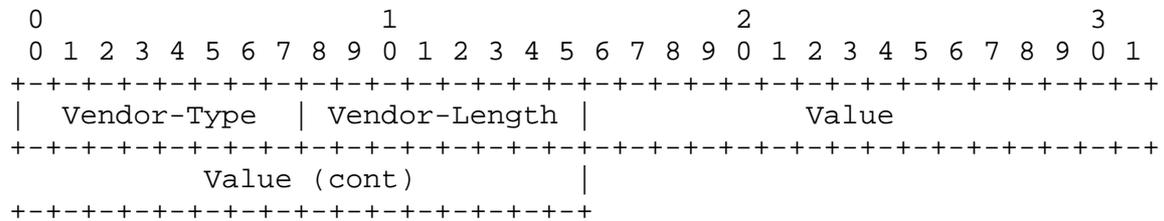
    Vendor-Type
        14 for MS-Link-Utilization-Threshold

    Vendor-Length 6

    Value The Value field is four octets in length and represents the
        percentage of available bandwidth utilization below which the link
        must fall before the link is eligible for termination.
        Permissible values are in the range 1-100, inclusive.

2.5.3.  MS-Link-Drop-Time-Limit

    Description

        The MS-Link-Drop-Time-Limit Attribute indicates the length of time
        (in seconds) that a link must be underutilized before it is
        dropped.  It MAY only be included in Access-Accept packets.

    A summary of the MS-Link-Drop-Time-Limit Attribute format is given
    below.  The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Vendor-Type  | Vendor-Length |               Value
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
         Value (cont)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
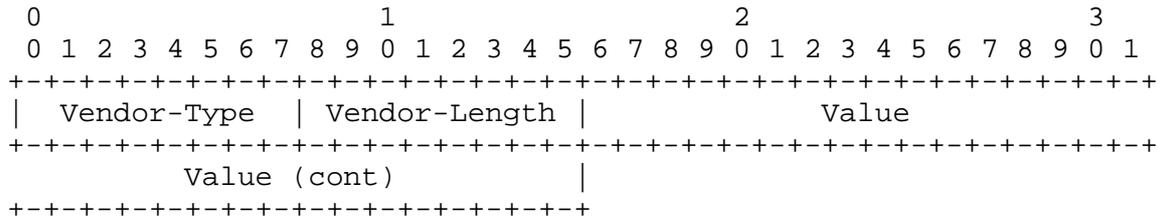
Vendor-Type
    15 for MS-Link-Drop-Time-Limit

Vendor-Length
    6

Value
    The Value field represents the number of seconds that a link must
    be underutilized (i.e., display bandwidth utilization below the
    threshold specified in the MS-Link-Utilization-Threshold
    Attribute) before the link is dropped.

2.6.  Attributes for ARAP Support

   This section describes a set of Attributes designed to support the
   Apple Remote Access Protocol (ARAP).

2.6.1.  MS-Old-ARAP-Password

   Description

      The MS-Old-ARAP-Password Attribute is used to transmit the old
      ARAP password during an ARAP password change operation.  It MAY be
      included in Access-Request packets.

   A summary of the MS-Old-ARAP-Password Attribute Attribute format is
   given below.  The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Vendor-Type  | Vendor-Length |            String...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
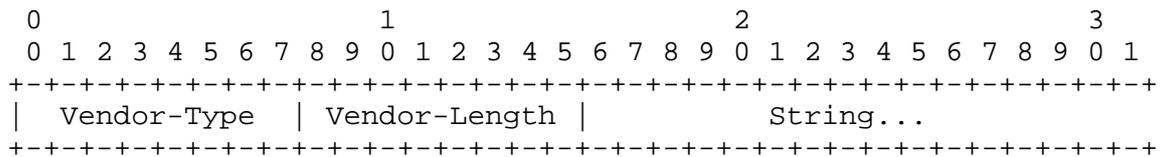
   Vendor-Type
      19 for MS-Old-ARAP-Password Attribute

   Vendor-Length
      > 3

String
   The String field is one or more octets.  It contains the old ARAP
   password DES-encrypted using itself as the key.

2.6.2.  MS-New-ARAP-Password

Description

   The MS-New-ARAP-Password Attribute is used to transmit the new
   ARAP password during an ARAP password change operation.  It MAY be
   included in Access-Request packets.

A summary of the MS-New-ARAP-Password Attribute Attribute format is
given below.  The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Vendor-Type  | Vendor-Length |           String...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
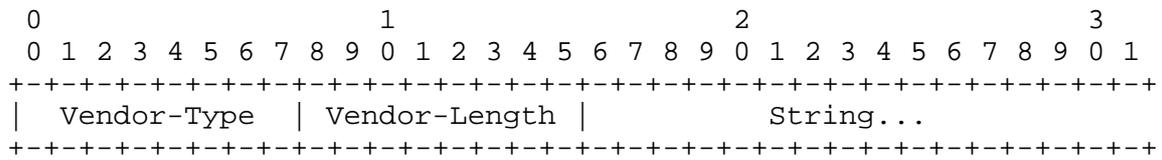
Vendor-Type
   20 for MS-New-ARAP-Password Attribute

Vendor-Length
   > 3

String
   The  String field is one or more octets.  It contains the new ARAP
   password DES-encrypted using the old ARAP password as the key.

2.6.3.  MS-ARAP-Password-Change-Reason

Description

   The MS-ARAP-Password-Change-Reason Attribute is used to indicate
   reason for a server-initiated password change.  It MAY be included
   in Access-Challenge packets.

A summary of the MS-ARAP-Password-Change-Reason Attribute format is
given below.  The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type   | Vendor-Length |            Why
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
          Why (cont)            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
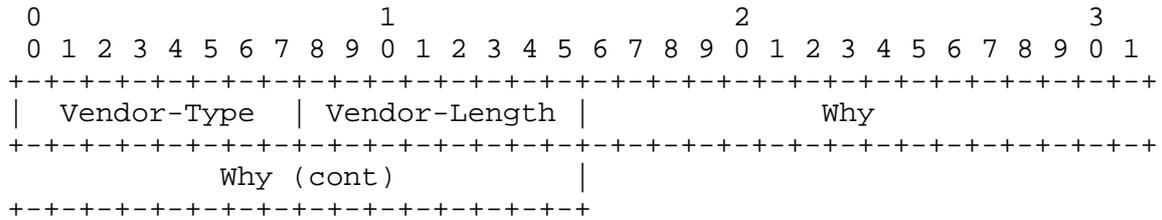
Vendor-Type
   21 for MS-ARAP-Password-Change-Reason

Vendor-Length
   6

Why
   The Why field is 4 octets in length.  The following values are
   defined:
       Just-Change-Password              1
       Expired-Password                  2
       Admin-Requires-Password-Change    3
       Password-Too-Short                4

2.6.4.  MS-ARAP-Challenge

   Description

      This attribute is only present in an Access-Request packet
      containing a Framed-Protocol Attribute with the value 3 (ARAP).

   A summary of the MS-ARAP-Challenge Attribute format is given below.
   The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type   | Vendor-Length |            Challenge
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       Challenge (cont)                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
         Challenge (cont)       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
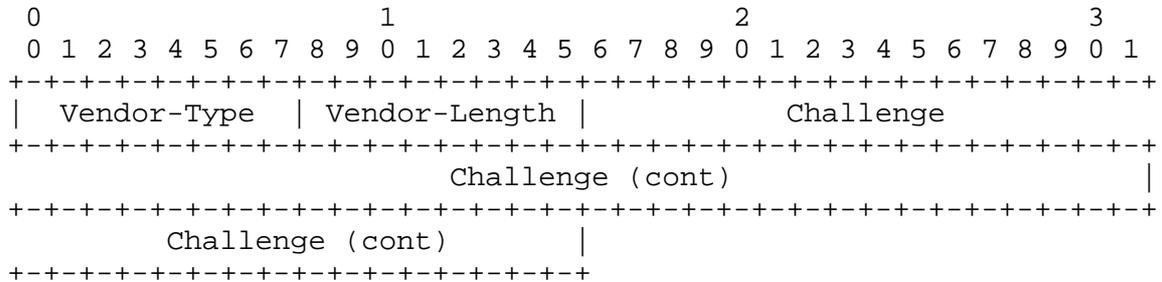
Vendor-Type
   33 for MS-ARAP-Challenge

Vendor-Length
   10

Value
    The Challenge Field is 8 octets in length.  It contains the
    challenge (as two 4-octet quantities) sent by the NAS to the peer.

2.7.  Miscellaneous Attributes

    This section describes attributes which do not fall into any
    particular category, but are used in the identification and operation
    of Microsoft remote access products.

2.7.1.  MS-RAS-Vendor

    Description

        The MS-RAS-Vendor Attribute is used to indicate the manufacturer
        of the RADIUS client machine.  It MAY be included in both Access-
        Request and Accounting-Request packets.

    A summary of the MS-RAS-Vendor Attribute format is given below.  The
    fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type   | Vendor-Length |          Vendor-ID
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
       Vendor-ID (cont)        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
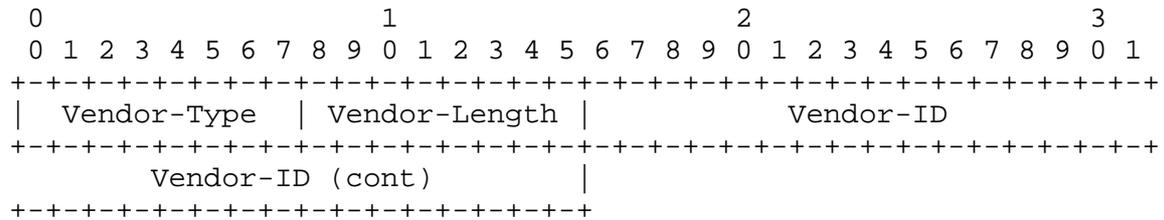
    Vendor-Type
        9 for MS-RAS-Vendor

    Vendor-Length
        6

    Vendor-ID
        The Vendor-ID field is 4 octets in length.  The high-order octet
        is 0 and the low-order 3 octets are the SMI Network Management
        Private Enterprise Code of the Vendor in network byte order, as
        defined in the Assigned Numbers RFC [13].

2.7.2.  MS-RAS-Version

    Description

        The MS-RAS-Version Attribute is used to indicate the version of
        the RADIUS client software.  This attribute SHOULD be included in
        packets containing an MS-RAS-Vendor Attribute; it SHOULD NOT be

      sent in packets which do not contain an MS-RAS-Vendor Attribute.
      It MAY be included in both Access-Request and Accounting-Request
      packets.

   A summary of the MS-RAS-Version Attribute format is given below.  The
   fields are transmitted left to right.

    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Vendor-Type   | Vendor-Length |           String...
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
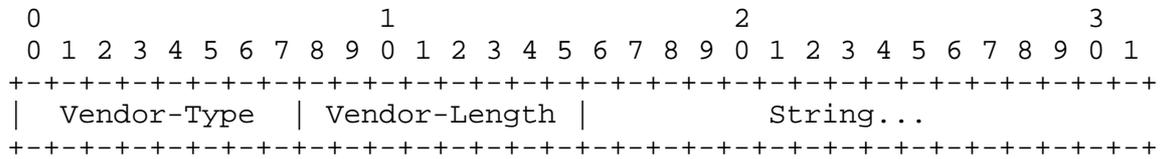
   Vendor-Type
      18 for MS-RAS-Version

   Vendor-Length
      > 3

   String
      The  String field is one or more octets.  The actual format of the
      information is vendor specific, and a robust implementation SHOULD
      support the field as undistinguished octets.

2.7.3.  MS-Filter

   Description

      The MS-Filter Attribute is used to transmit traffic filters.  It
      MAY be included in both Access-Accept and Accounting-Request
      packets.

      If multiple MS-Filter Attributes are contained within a packet,
      they MUST be in order and they MUST be consecutive attributes in
      the packet.

   A summary of the MS-Filter Attribute format is given below.  The
   fields are transmitted left to right.

    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Vendor-Type   | Vendor-Length |           Filter...
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
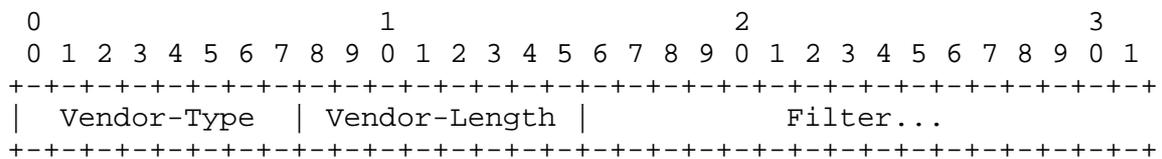
   Vendor-Type
      22 for MS-Filter Attribute

   Vendor-Length
      > 3

   Filter
      The Filter field is one or more octets.  It contains a sequence of
      undifferentiated octets.

      If multiple MS-Filter Attributes occur in a single Access-Accept
      packet, the Filter field from each MUST be concatenated in the
      order received to form the actual filter.

2.7.4.  MS-Acct-Auth-Type

   Description

      The MS-Acct-Auth-Type Attribute is used to represent the method
      used to authenticate the dial-up user.  It MAY be included in
      Accounting-Request packets.

   A summary of the MS-Acct-Auth-Type Attribute format is given below.
   The fields are transmitted left to right.

    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  Vendor-Type  | Vendor-Length |          Auth-Type
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
          Auth-Type (cont)        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
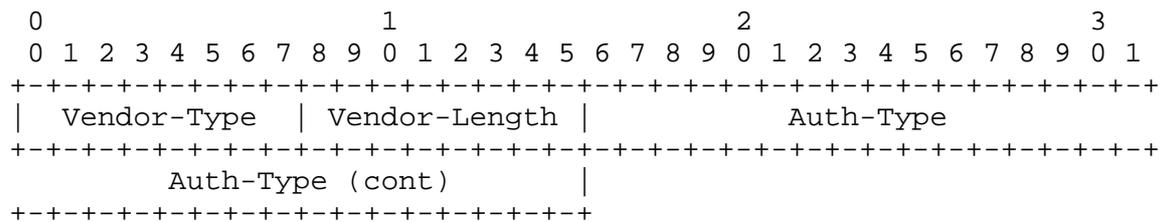
   Vendor-Type
      23 for MS-Acct-Auth-Type

   Vendor-Length
      6

   Auth-Type
      The Auth-Type field is 4 octets in length.  The following values
      are defined for this field:

         PAP                1
         CHAP               2
         MS-CHAP-1          3
         MS-CHAP-2          4
         EAP                5

2.7.5.  MS-Acct-EAP-Type

   Description

      The MS-Acct-EAP-Type Attribute is used to represent the Extensible
      Authentication Protocol (EAP) [15] type used to authenticate the
      dial-up user.  It MAY be included in Accounting-Request packets.

   A summary of the MS-Acct-EAP-Type Attribute format is given below.
   The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type   | Vendor-Length |            EAP-Type
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
         EAP-Type (cont)        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
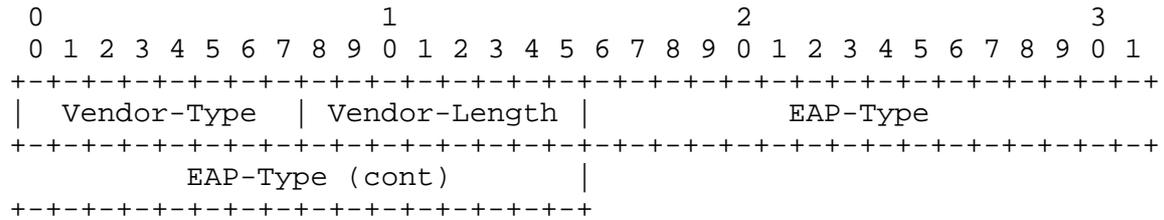
   Vendor-Type
      24 for MS-Acct-EAP-Type

   Vendor-Length
      6

   Auth-Type
      The EAP-Type field is 4 octets in length.  The following values
      are currently defined for this field:

         MD5                    4
         OTP                    5
         Generic Token Card     6
         TLS                    13

2.7.6.  MS-Primary-DNS-Server

   Description

      The MS-Primary-DNS-Server Attribute is used to indicate the
      address of the primary Domain Name Server (DNS) [16, 17] server to
      be used by the PPP peer.  It MAY be included in both Access-Accept
      and Accounting-Request packets.

   A summary of the MS-Primary-DNS-Server Attribute format is given
   below.  The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type  | Vendor-Length |           IP-Address
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        IP-Address (cont)       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
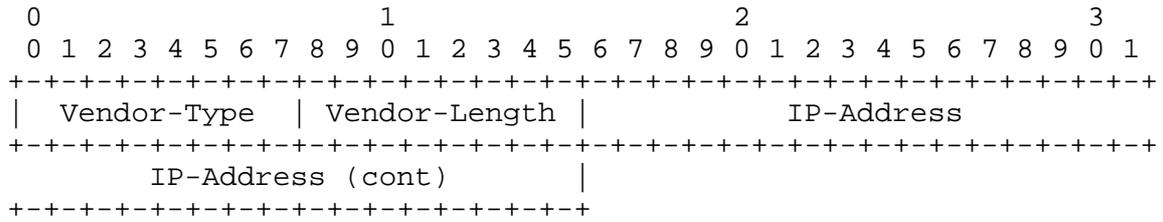
Vendor-Type
   28 for MS-Primary-DNS-Server

Vendor-Length
   6

IP-Address
   The IP-Address field is 4 octets in length.  It contains the IP
   address of the primary DNS server.

2.7.7.  MS-Secondary-DNS-Server

   Description

      The MS-Secondary-DNS-Server Attribute is used to indicate the
      address of the secondary DNS server to be used by the PPP peer.
      It MAY be included in both Access-Accept and Accounting-Request
      packets.

   A summary of the MS-Secondary-DNS-Server Attribute format is given
   below.  The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type  | Vendor-Length |           IP-Address
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
        IP-Address (cont)       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
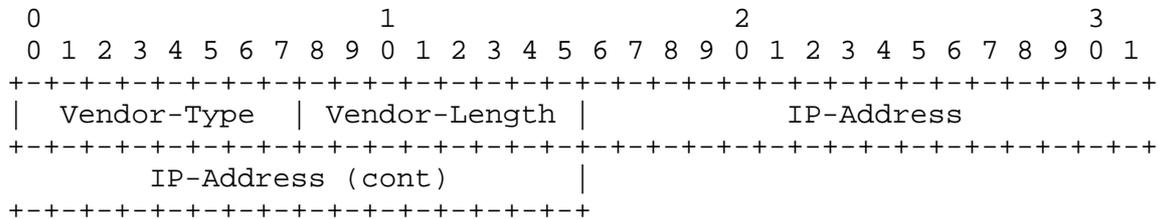
Vendor-Type
   29 for MS-Secondary-DNS-Server

Vendor-Length
   6

IP-Address
   The IP-Address field is 4 octets in length.  It contains the IP
   address of the secondary DNS server.

2.7.8.  MS-Primary-NBNS-Server

   Description

      The MS-Primary-NBNS-Server Attribute is used to indicate the
      address of the primary NetBIOS Name Server (NBNS) [18] server to
      be used by the PPP peer.  It MAY be included in both Access-Accept
      and Accounting-Request packets.

   A summary of the MS-Primary-MBNS-Server Attribute format is given
   below.  The fields are transmitted left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Vendor-Type  | Vendor-Length |           IP-Address
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
         IP-Address (cont)      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
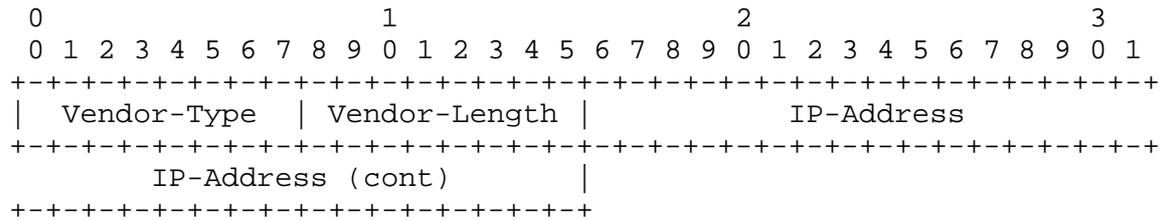
   Vendor-Type
      30 for MS-Primary-NBNS-Server

   Vendor-Length
      6

   IP-Address
      The IP-Address field is 4 octets in length.  It contains the IP
      address of the primary NBNS server.

2.7.9.  MS-Secondary-NBNS-Server

   Description

      The MS-Secondary-NBNS-Server Attribute is used to indicate the
      address of the secondary DNS server to be used by the PPP peer.
      It MAY be included in both Access-Accept and Accounting-Request
      packets.

   A summary of the MS-Secondary-NBNS-Server Attribute format is given
   below.  The fields are transmitted left to right.

```
    0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Vendor-Type   | Vendor-Length |          IP-Address
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
       IP-Address (cont)       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
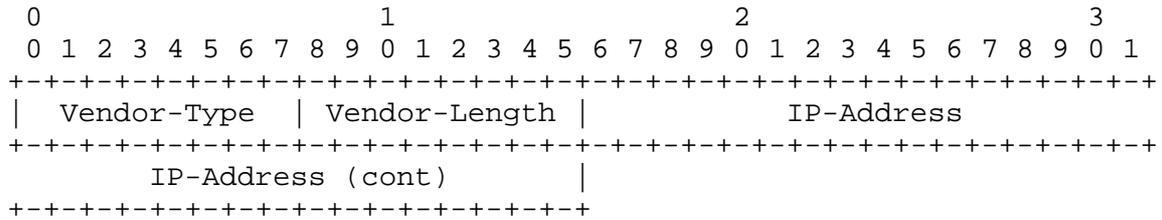
   Vendor-Type
      31 for MS-Secondary-NBNS-Server

   Vendor-Length
      6

   IP-Address
      The IP-Address field is 4 octets in length.  It contains the IP
      address of the secondary NBNS server.

3.  Table of Attributes

   The following table provides a guide to which of the above attributes
   may be found in which kinds of packets, and in what quantity.

| Request | Accept | Reject | Challenge | Acct-Request | # | Attribute |
|---------|--------|--------|-----------|--------------|---|-----------|
| 0-1 | 0 | 0 | 0 | 0 | 1 | MS-CHAP-Response |
| 0 | 0 | 0-1 | 0 | 0 | 2 | MS-CHAP-Error |
| 0-1 | 0 | 0 | 0 | 0 | 3 | MS-CHAP-CPW-1 |
| 0-1 | 0 | 0 | 0 | 0 | 4 | MS-CHAP-CPW-2 |
| 0+ | 0 | 0 | 0 | 0 | 5 | MS-CHAP-LM-Enc-PW |
| 0+ | 0 | 0 | 0 | 0 | 6 | MS-CHAP-NT-Enc-PW |
| 0 | 0-1 | 0 | 0 | 0 | 7 | MS-MPPE-Encryption-Policy |
| 0 | 0-1 | 0 | 0 | 0 | 8 | MS-MPPE-Encryption-Type |
| 0-1 | 0 | 0 | 0 | 0-1 | 9 | MS-RAS-Vendor |
| 0 | 0-1 | 0 | 0 | 0-1 | 10 | MS-CHAP-Domain |
| 0-1 | 0 | 0 | 0-1 | 0 | 11 | MS-CHAP-Challenge |
| 0 | 0-1 | 0 | 0 | 0 | 12 | MS-CHAP-MPPE-Keys |
| 0 | 0-1 | 0 | 0 | 0 | 13 | MS-BAP-Usage |
| 0 | 0-1 | 0 | 0 | 0 | 14 | MS-Link-Utilization-Threshold |
| 0 | 0-1 | 0 | 0 | 0 | 15 | MS-Link-Drop-Time-Limit |
| 0 | 0-1 | 0 | 0 | 0 | 16 | MS-MPPE-Send-Key |
| 0 | 0-1 | 0 | 0 | 0 | 17 | MS-MPPE-Recv-Key |
| 0-1 | 0 | 0 | 0 | 0-1 | 18 | MS-RAS-Version |
| 0-1 | 0 | 0 | 0 | 0 | 19 | MS-Old-ARAP-Password |
| 0-1 | 0 | 0 | 0 | 0 | 20 | MS-New-ARAP-Password |
| 0 | 0 | 0 | 0-1 | 0 | 21 | MS-ARAP-PW-Change-Reason |

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0+ | 0 | 0 | 0+ | 22 MS-Filter |
| 0 | 0 | 0 | 0 | 0-1 | 23 MS-Acct-Auth-Type |
| 0 | 0 | 0 | 0 | 0-1 | 24 MS-Acct-EAP-Type |
| 0-1 | 0 | 0 | 0 | 0 | 25 MS-CHAP2-Response |
| 0 | 0-1 | 0 | 0 | 0 | 26 MS-CHAP2-Success |
| 0-1 | 0 | 0 | 0 | 0 | 27 MS-CHAP2-CPW |
| 0 | 0-1 | 0 | 0 | 0-1 | 28 MS-Primary-DNS-Server |
| 0 | 0-1 | 0 | 0 | 0-1 | 29 MS-Secondary-DNS-Server |
| 0 | 0-1 | 0 | 0 | 0-1 | 30 MS-Primary-NBNS-Server |
| 0 | 0-1 | 0 | 0 | 0-1 | 31 MS-Secondary-NBNS-Server |
| 0-1 | 0 | 0 | 0 | 0 | 33 MS-ARAP-Challenge |

The following table defines the meaning of the above table entries.

0     This attribute MUST NOT be present in packet.
0+    Zero or more instances of this attribute MAY be present in packet.
0-1   Zero or one instance of this attribute MAY be present in packet.

4.  Security Considerations

   MS-CHAP, like PPP CHAP, is susceptible to dictionary attacks.  User
   passwords should be chosen with care, and be of sufficient length to
   deter easy guessing.

   Although the scheme used to protect the Keys field of the MS-CHAP-
   MPPE-Keys, MS-MPPE-Send-Key and MS-MPPE-Recv-Key Attributes is
   believed to be relatively secure on the wire, RADIUS proxies will
   decrypt and re-encrypt the field for forwarding.  Therefore, these
   attributes SHOULD NOT be used on networks where untrusted RADIUS
   proxies reside.

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                RSA Data Security, Inc.
                100 Marine Parkway
                Redwood City, CA 94065-1031

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