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Microsoft's PEAP version 0 (Implementation in Windows XP SP1)

Abstract

This specification documents the implementation of PEAP supported in Windows XP SP1. This implementation utilizes a version number of zero (0) and supports acknowledged and protected success and failure indications, using the EAP Extensions method, Type 33.

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1. Introduction

Microsoft's Windows XP SP1 implementation of PEAP version 0 differs in the following ways from the protocol specified in [PEAP].

Version field
EAP encapsulation
Acknowledged and protected success and failure using EAP extensions method

PEAP protocol [PEAP] supports versioning and hence servers and clients can
support multiple versions of the protocol. [PEAP] is currently at version 1.
Each of these differences is explained in the sections that follow.

1.1. EAP encapsulation

The [PEAP] specification requires that EAP packets be tunneled within a TLS channel in their entirety. However, the Windows XP SP1 implementation of PEAP does not include an EAP header on packets sent within the TLS channel, except for EAP Extension packets (Type 33), where the complete header is sent. As a result, for EAP Types other than 33, the Code, Identifier, and Length fields are not sent, but rather EAP packets sent within the PEAP tunnel begin with the Type field.

While the Code, Identifier and Length fields are not sent over the wire,
they are reconstructed at the receiver prior to EAP processing. For example, the Code and Identifier fields of the tunneled EAP packet are assumed to be the same as the equivalent fields within the outer EAP header, and the Length field of the tunneled EAP packet is derived from the Length field of the PEAP packet. This has the following implications:

[a] The Code field of the tunneled EAP packet is assumed to be the same
as the Code field of the PEAP packet. This may not always be the case; for example, an EAP Success or Failure packet (Code 3 and 4) may be tunneled within a PEAP Request packet (Code 1). This means that the Windows XP SP1 implementation of PEAP is incapable of tunneling arbitrary EAP packets.

[b] Since the full EAP header is sent for the EAP Extensions type (Type
33), but not for other Types, it is difficult for the implementation to distinguish an Extensions Request (Code 1) from an EAP Type 1 (Identity) Request packet. In practice, this implies
that the Windows XP SP1 PEAP implementation can only support authentication using a single EAP method per session.

1.2. Version Field

[PEAP] is currently a work-in-progress. In order to allow for backward compatibility once the final specification of PEAP is completed, a version field of zero (0) is used, rather than the value of one (1) required for conformant implementations as specified in [PEAP].

Note that use of distinct version numbers enables backward compatibility
once the final specification of PEAP is complete. Version negotiation takes place at the start of the conversation, with the authenticator indicating its highest supported version. The peer then responds with the highest version it supports. The conversation will then occur using the highest version supported by both parties. This behavior is illustrated in the last example in Appendix A.

1.3. EAP extensions method

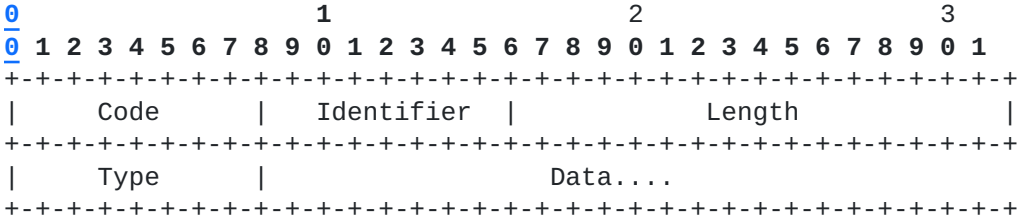
The [PEAP] termination mechanism (sending an encrypted EAP Success or EAP Failure packet) does not function correctly with Authenticators implementing [IEEE8021X]. Since IEEE 802.1X authenticators "manufacture"
a clear-text EAP Success based on receipt of a RADIUS Access-Accept, or a clear-text EAP Failure based on receipt of a RADIUS Access-Reject, unless an acknowledged success/failure indication is used, the PEAP Supplicant may never receive a protected success/failure indication. This leaves the PEAP Supplicant open to attack. As a result, the Windows
XP SP1 PEAP implementation supports acknowledged and protected success/failure indications, using the EAP Extensions method (Type 33).

2. Details of EAP extensions method

The packet formats for the EAP Extensions method (type 33) follow.

2.1. Extensions Request Packet

A summary of the Extensions Request packet format is shown below. The fields are transmitted from left to right.



Code

Identifier

The Identifier field is one octet and aids in matching responses with requests. The Identifier field MUST be changed on each Request packet.

Length

The Length field is two octets and indicates the length of the EAP packet including the Code, Identifier, Length, Type, and Data fields.

Type

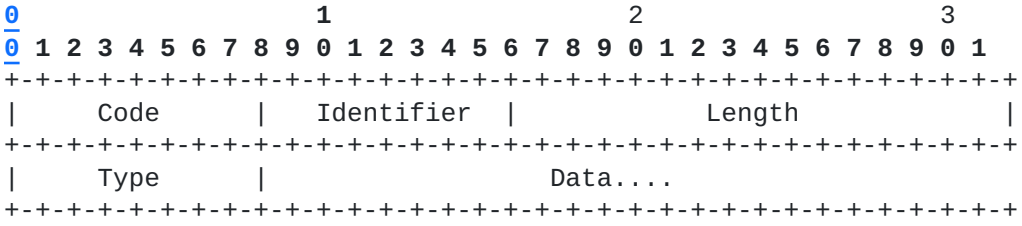
33 - EAP Extensions

Data

The Data field is of variable length, and contains Attribute-Value Pairs (AVPs).

2.2. Extensions Response Packet

A summary of the Extensions Response packet format is shown below. The fields are transmitted from left to right.



Code

2

Identifier

The Identifier field is one octet and aids in matching responses with requests. The Identifier field MUST be changed on each Request packet.

Length

The Length field is two octets and indicates the length of the EAP packet including the Code, Identifier, Length, Type, and Data fields.

Type

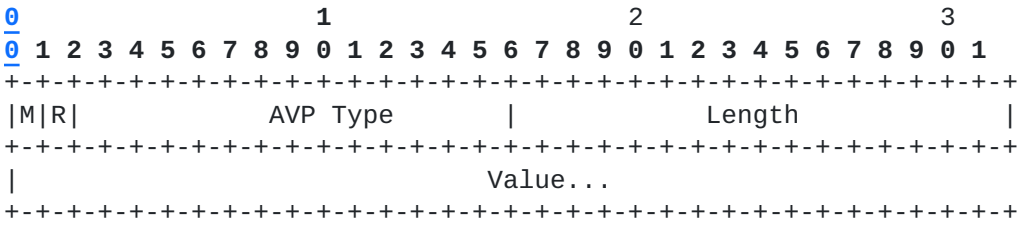
33 - EAP Extensions

Data

The Data field is of variable length, and contains Attribute-Value Pairs (AVPs).

2.3. AVP format

Extensions AVPs are defined as follows:



M

0 - Non-mandatory AVP
1 - Mandatory AVP

R

Reserved, set to zero (0)

AVP Type

A 14-bit field, denoting the attribute type. Allocated AVP Types include:

0 - Reserved
1 - Reserved
2 - Reserved
3 - Acknowledged Result

Length

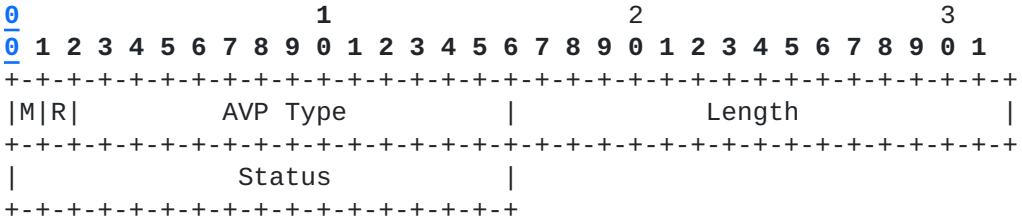
The length of the value field in octets.

Value

The value of the attribute.

2.3.1. Result AVP

The Result AVP provides support for acknowledged Success and Failure within EAP. It is defined as follows:



M

1 - Mandatory AVP

R

Reserved, set to zero (0)

AVP Type

3 - Result

Length

2

Status

The status field is two octets. Values include:

1 - Success
2 - Failure

3. Security considerations

3.1. Authentication and integrity protection

The EAP Extension method is presumed to run before or after an EAP method that supports mutual authentication and establishes a protected channel. PEAP is such a method, and as a result the acknowledged Success and Failure messages are always protected.

Note however, that [IEEE8021X] manufactures clear-text EAP Success and EAP Failure messages, so that even though the Result AVP will be protected, this will be followed by a clear-text EAP Success or EAP

Failure packet.

3.2. Outcomes

Within the Microsoft PEAP Version 0 implementation, support for the EAP Extensions method and the Result AVP is required. The only outcome which
should be considered a successful authentication is when an EAP Request of Type=Extensions with Result AVP of Status=Success is answered by an EAP Response of Type=Extensions with Result AVP of Status=Success. All other combinations (Extensions Success, Extensions Failure), (Extensions
Failure, Extensions Success), (Extensions Failure, Extensions Failure), (No extensions exchange) should be considered failed authentications, both by the EAP Peer and EAP Server. This is true regardless of whether an EAP Success or EAP Failure packet is subsequently sent, either in clear-text or within the PEAP tunnel. Because the EAP Extensions method is protected within the PEAP channel, its messages cannot be spoofed, whereas clear-text Success and Failure messages can be sent by an attacker.

While the [PEAP] specification permits a tunneled EAP Success or Failure
packet to be sent as the last message, this is not possible within the Windows XP SP1 implementation, which can only tunnel EAP packets of codes Request or Response within PEAP. Since the [IEEE8021X] specification requires that the switch or access point "manufacture" a clear-text EAP Success packet when an Access-Accept is received from the
backend authentication server, and a clear-text EAP Failure packet when an Access-Reject is received. As a result, a tunneled EAP Success or Failure packet, if sent as the last message, would be thrown away by conformant [IEEE 8021X] implementations, and replaced with clear-text. This problem is being addressed within the IEEE 802.1aa revision to IEEE
802.1X, but the fix may take a while to move through the standards process and be implemented in commercial products.

4. Normative references

[PEAP] Andersson, H., et al. "Protected EAP Protocol", Internet draft (work in progress), draft-josefsson-pppext-eap-tls-
eap-02.txt, February 2002.

[RFC1661] Simpson, W., Editor, "The Point-to-Point Protocol (PPP)",
STD 51, RFC 1661, July 1994.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC2284] Blunk, L., Vollbrecht, J., "PPP Extensible Authentication Protocol (EAP)", RFC 2284, March 1998.

[IEEE8021X] IEEE Standards for Local and Metropolitan Area Networks: Port based Network Access Control, IEEE Std 802.1X-2001, June 2001.

5. Informative references

[IEEE80211] Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific Requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, IEEE Std. 802.11-1999, 1999.

Appendix A - Examples

In the case where an identity exchange occurs within PEAP Part 1, the conversation will appear as follows:

```
Authenticating Peer     Authenticator
-------------------     -------------
                        <- EAP-Request/
                        Identity
EAP-Response/
Identity (MyID) ->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (PEAP Start, S bit set)

EAP-Response/
EAP-Type=PEAP, V=0
(TLS client_hello)->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS server_hello,
                         TLS certificate,
                 [TLS server_key_exchange,]
                 [TLS certificate_request,]
                     TLS server_hello_done)
EAP-Response/
EAP-Type=PEAP, V=0
([TLS certificate,]
 TLS client_key_exchange,
[TLS certificate_verify,]
 TLS change_cipher_spec,
 TLS finished) ->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS change_cipher_spec,
                         TLS finished)
EAP-Response/
EAP-Type=PEAP ->

TLS channel established
(messages sent within the TLS channel)

                       <- EAP-Request/
                        Identity
EAP-Response/
Identity (MyID) ->
                       <- EAP-Request/
                        EAP-Type=X
```

```
EAP-Response/
EAP-Type=X or NAK ->

                       <- EAP-Request/
                        EAP-Type=X
EAP-Response/
EAP-Type=X  ->
                        <- EAP-Request/
                           EAP-Type=Extensions
                           Result=Success
EAP-Response/
EAP-Type=Extensions
Result=Success  ->

TLS channel torn down
(messages sent in clear-text)

                        <- EAP-Success
```

In the case where the PEAP fragmentation is required, the conversation will appear as follows:

```
Authenticating Peer     Authenticator
-------------------     -------------
                        <- EAP-Request/
                        Identity
EAP-Response/
Identity (MyID) ->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (PEAP Start, S bit set)

EAP-Response/
EAP-Type=PEAP, V=0
(TLS client_hello)->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS server_hello,
                         TLS certificate,
                 [TLS server_key_exchange,]
                 [TLS certificate_request,]
                     TLS server_hello_done)
                 (Fragment 1: L, M bits set)
EAP-Response/
EAP-Type=PEAP, V=0 ->
                        <- EAP-Request/
                           EAP-Type=PEAP, V=0
                        (Fragment 2: M bit set)
```

```
EAP-Response/
EAP-Type=PEAP, V=0 ->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (Fragment 3)
EAP-Response/
EAP-Type=PEAP, V=0
([TLS certificate,]
 TLS client_key_exchange,
[TLS certificate_verify,]
 TLS change_cipher_spec,
 TLS finished)
 (Fragment 1: L, M bits set)->

                         <- EAP-Request/
                        EAP-Type=PEAP, V=0
EAP-Response/
EAP-Type=PEAP, V=0
(Fragment 2)->
                       <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS change_cipher_spec,
                         TLS finished)

EAP-Response/
EAP-Type=PEAP, V=0 ->

TLS channel established
(messages sent within the TLS channel)

                       <- EAP-Request/
                        Identity
EAP-Response/
Identity (MyID) ->
                       <- EAP-Request/
                        EAP-Type=X
EAP-Response/
EAP-Type=X or NAK ->

                       <- EAP-Request/
                        EAP-Type=X
EAP-Response/
EAP-Type=X  ->
                        <- EAP-Request/
                           EAP-Type=Extensions
                           Result=Success
EAP-Response/
EAP-Type=Extensions
```

```
Result=Success  ->

TLS channel torn down
(messages sent in clear-text)

                        <- EAP-Success

In the case where the server authenticates to the client
successfully in PEAP Part 1, but the client fails to authenticate
to the server in PEAP Part 2, the conversation will appear as follows:

Authenticating Peer     Authenticator
-------------------     -------------
                        <- EAP-Request/
                        Identity
EAP-Response/
Identity (MyID) ->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (PEAP Start, S bit set)
EAP-Response/
EAP-Type=PEAP, V=0
(TLS client_hello)->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS server_hello,
                         TLS certificate,
                 [TLS server_key_exchange,]
                 [TLS certificate_request,]
                     TLS server_hello_done)
EAP-Response/
EAP-Type=PEAP, V=0
([TLS certificate,]
 TLS client_key_exchange,
[TLS certificate_verify,]
 TLS change_cipher_spec,
 TLS finished) ->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS change_cipher_spec,
                         TLS finished)

EAP-Response/
EAP-Type=PEAP, V=0 ->

TLS channel established
(messages sent within the TLS channel)
```

```
                       <- EAP-Request/
                        Identity
EAP-Response/
Identity (MyID) ->
                       <- EAP-Request/
                        EAP-Type=X
EAP-Response/
EAP-Type=X or NAK ->

                       <- EAP-Request/
                        EAP-Type=X
EAP-Response/
EAP-Type=X  ->
                        <- EAP-Request/
                           EAP-Type=Extensions
                           Result=Failure
EAP-Response/
EAP-Type=Extensions
Result=Failure  ->

(TLS session cache entry flushed)
TLS channel torn down
(messages sent in clear-text)

                        <- EAP-Failure
```

In the case where server authentication is unsuccessful in PEAP Part 1, the conversation will appear as follows:

```
Authenticating Peer     Authenticator
-------------------     -------------
                        <- EAP-Request/
                        Identity
EAP-Response/
Identity (MyID) ->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (PEAP Start)
EAP-Response/
EAP-Type=PEAP, V=0
(TLS client_hello)->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS server_hello,
                         TLS certificate,
                 [TLS server_key_exchange,]
                     TLS server_hello_done)
EAP-Response/
```

```
EAP-Type=PEAP, V=0
(TLS client_key_exchange,
[TLS certificate_verify,]
 TLS change_cipher_spec,
 TLS finished) ->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS change_cipher_spec,
                         TLS finished)
EAP-Response/
EAP-Type=PEAP, V=0
(TLS change_cipher_spec,
TLS finished)

                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
EAP-Response/
EAP-Type=PEAP, V=0
(TLS Alert message) ->
                        <- EAP-Failure
                        (TLS session cache entry flushed)
```

In the case where a previously established session is being resumed, the EAP server supports TLS session cache flushing for unsuccessful PEAP Part 2 authentications and both sides authenticate successfully, the conversation will appear as follows:

```
Authenticating Peer     Authenticator
-------------------     -------------
                        <- EAP-Request/
                        Identity
EAP-Response/
Identity (MyID) ->
                        <- EAP-Request/
                        EAP-Type=PEAP,V=0
                        (PEAP Start)
EAP-Response/
EAP-Type=PEAP, V=0
(TLS client_hello)->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS server_hello,
                        TLS change_cipher_spec
                        TLS finished)
EAP-Response/
EAP-Type=PEAP, V=0
(TLS change_cipher_spec,
```

```
 TLS finished) ->
                        <- EAP-Request/
                           EAP-Type=Extensions
                           Result=Success
EAP-Response/
EAP-Type=Extensions
Result=Success  ->
TLS channel torn down
(messages sent in clear-text)

                        <- EAP-Success
```

In the case where a previously established session is being resumed, and the server authenticates to the client successfully but the client fails to authenticate to the server, the conversation will appear as follows:

```
Authenticating Peer     Authenticator
-------------------     -------------
                        <- EAP-Request/
                        Identity
EAP-Response/
Identity (MyID) ->
                        <- EAP-Request/
                        EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS Start)
EAP-Response/
EAP-Type=PEAP, V=0
(TLS client_hello) ->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS server_hello,
                         TLS change_cipher_spec,
                         TLS finished)
EAP-Response/
EAP-Type=PEAP, V=0
(TLS change_cipher_spec,
 TLS finished) ->
                        <- EAP-Request
                        EAP-Type=PEAP, V=0
                        (TLS Alert message)
EAP-Response
EAP-Type=PEAP, V=0 ->
                         <- EAP-Failure
                         (TLS session cache entry flushed)
```

In the case where a previously established session is being resumed,

and the server authentication is unsuccessful,
the conversation will appear as follows:

```
Authenticating Peer     Authenticator
-------------------     -------------
                       <- EAP-Request/
                        Identity
EAP-Response/
Identity (MyID) ->
                        <- EAP-Request/
                        EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS Start)
EAP-Response/
EAP-Type=PEAP, V=0
(TLS client_hello)->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS server_hello,
                         TLS change_cipher_spec,
                         TLS finished)
EAP-Response/
EAP-Type=PEAP, V=0
(TLS change_cipher_spec,
TLS finished)
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
EAP-Response/
EAP-Type=PEAP, V=0
(TLS Alert message) ->
(TLS session cache entry flushed)

                        <- EAP-Failure
```

In the case where the peer and authenticator have mismatched PEAP
versions
(e.g. the peer has a pre-standard implementation
with version 0, and the authenticator has a Version 1 implementation,
but the authentication is unsuccessful, the conversation will occur as
follows:

```
Authenticating Peer     Authenticator
-------------------     -------------
                       <- EAP-Request/
                        Identity
EAP-Response/
Identity (MyID) ->
                        <- EAP-Request/
                        EAP-Request/
                        EAP-Type=PEAP, V=1
```

```
                        (TLS Start)
EAP-Response/
EAP-Type=PEAP, V=0
(TLS client_hello)->
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
                        (TLS server_hello,
                         TLS change_cipher_spec,
                         TLS finished)
EAP-Response/
EAP-Type=PEAP, V=0
(TLS change_cipher_spec,
TLS finished)
                        <- EAP-Request/
                        EAP-Type=PEAP, V=0
EAP-Response/
EAP-Type=PEAP, V=0
(TLS Alert message) ->
(TLS session cache entry flushed)

                         <- EAP-Failure
```

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