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Port Control Protocol (PCP) Authentication Mechanism
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Abstract

An IPv4 or IPv6 host can use the Port Control Protocol (PCP) to flexibly manage the IP address and port mapping information on Network Address Translators (NATs) or firewalls, to facilitate communication with remote hosts. However, the un-controlled generation or deletion of IP address mappings on such network devices may cause security risks and should be avoided. In some cases the client may need to prove that it is authorized to modify, create or delete PCP mappings. This document describes an in-band authentication mechanism for PCP that can be used in those cases. The Extensible Authentication Protocol (EAP) is used to perform authentication between PCP devices.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on November 23, 2015.

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1. Introduction

Using the Port Control Protocol (PCP) [RFC6887], an application can flexibly manage the IP address mapping information on its network address translators (NATs) and firewalls, and control their policies in processing incoming and outgoing IP packets. Because NATs and firewalls both play important roles in network security architectures, there are many situations in which authentication and access control are required to prevent un-authorized users from accessing such devices. This document proposes a PCP security extension which enables PCP servers to authenticate their clients with Extensible Authentication Protocol (EAP). The EAP messages are encapsulated within PCP messages during transportation.

The following issues are considered in the design of this extension:

- Loss of EAP messages during transportation
- Reordered delivery of EAP messages
- Generation of transport keys
- Integrity protection and data origin authentication for PCP messages
- Algorithm agility

The mechanism described in this document meets the security requirements to address the Advanced Threat Model described in the base PCP specification [RFC6887]. This mechanism can be used to secure PCP in the following situations:

- On security infrastructure equipment, such as corporate firewalls, that do not create implicit mappings for specific traffic.

- On equipment (such as CGNs or service provider firewalls) that serve multiple administrative domains and do not have a mechanism to securely partition traffic from those domains.

- For any implementation that wants to be more permissive in authorizing applications to create mappings for successful inbound communications destined to machines located behind a NAT or a firewall.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

Most of the terms used in this document are introduced in [RFC6887].

PCP Client: A PCP software instance which is responsible for issuing PCP requests to a PCP server. In this document, a PCP client is also a EAP peer [RFC3748], and it is the responsibility of a PCP client to provide the credentials when authentication is required.

PCP Server: A PCP software instance that resides on the PCP-Controlled Device that receives PCP requests from the PCP client and creates appropriate state in response to that request. In this document, a PCP server is integrated with an EAP authenticator [RFC3748]. Therefore, when necessary, a PCP server can verify the credentials provided by a PCP client and make an access control decision based on the authentication result.

PCP-Authentication (PA) Session: A series of PCP message exchanges transferred between a PCP client and a PCP server. The PCP messages involved within a session includes the PCP Authentication (PA) messages used to perform EAP authentication, key distribution and session management, and the common PCP messages secured with the keys distributed during authentication. Each PA session is assigned a distinctive Session ID.

Session Partner: A PCP implementation involved within a PA session. Each PA session has two session partners (a PCP server and a PCP client).

Session Lifetime: The lifetime associated with a PA session, which decides the lifetime of the current authorization given to the PCP client.

PCP Security Association (PCP SA): A PCP security association is formed between a PCP client and a PCP server by sharing cryptographic keying material and associated context. The formed duplex security association is used to protect the bidirectional PCP signaling traffic between the PCP client and PCP server.

Master Session Key (MSK): A key derived by the partners of a PA session, using an EAP key generating method (e.g., the one defined in [RFC5448]).

PCP-Authentication (PA) message: A PCP message containing an Authentication Opcode. Particularly, a PA message sent from a PCP server to a PCP client is referred to as a PA-Server, while a PA message sent from a PCP client to a PCP server is referred to as a PA-Client. Therefore, a PA-Server is actually a PCP response message specified in [RFC6887], and a PA-Client is a PCP request message. This document specifies an option, the Authentication Tag Option defined in Section 5.4 for PCP authentication, to provide integrity protection and message origin authentication for PA messages.

Common PCP message: A PCP message which does not contain an Authentication Opcode. This document specifies an Authentication Tag Option to provide integrity protection and message origin authentication for the common PCP messages.

3. Protocol Details

3.1. Session Initiation

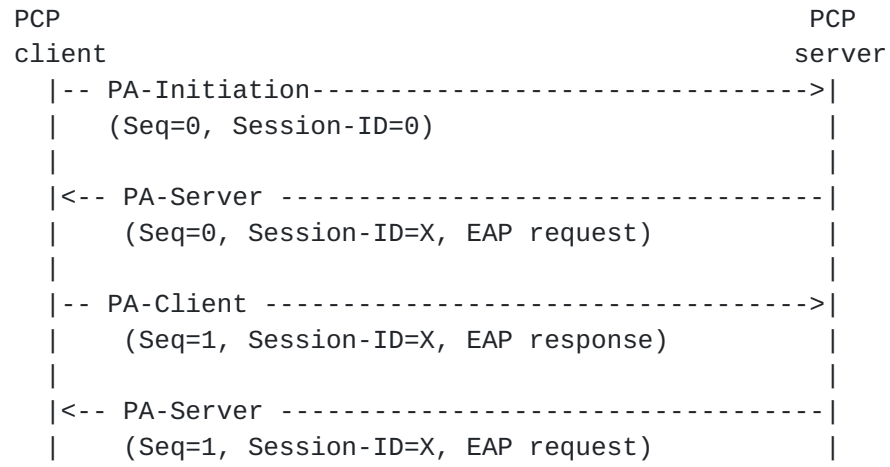
At the beginning of a PA session, a PCP client and a PCP server need to exchange a series of PA messages in order to perform an EAP authentication process. Each PA message is attached with an Authentication Opcode and may optionally contain a set of Options for various purposes (e.g., transporting authentication messages and session management). The Authentication Opcode consists of two fields: Session ID and Sequence Number. The Session ID field is used to identify the PA session to which the message belongs. The sequence number field is used to detect the reordering or the duplication occurred during message delivery.

3.1.1. Authentication triggered by the client

When a PCP client intends to proactively initiate a PA session with a PCP server, it sends a PA-Initiation message (a PA-Client message with the result code "INITIATION") to the PCP server. Section 5.1 updates the PCP request message format to have a result code. In the message, the Session ID and Sequence Number fields of the Authentication Opcode are set as 0. The PCP client SHOULD also

append a nonce option defined in Section 5.3 which consists of a random nonce with the message.

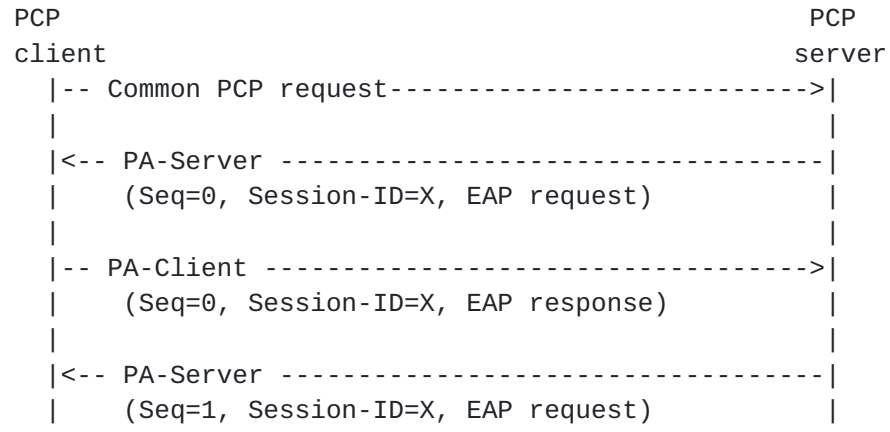
After receiving the PA-Initiation, if the PCP server agrees to initiate a PA session with the PCP client, it will reply with a PA-Server message which contains an EAP Identity Request, and the result code field of this PA-Server message is set to AUTHENTICATION-REQUIRED. In addition, the server MUST assign a random session identifier to distinctly identify this session, and fill the identifier into the Session ID field of the Authentication Opcode in the PA-Server message. The Sequence Number field of the Authentication Opcode is set as 0. If there is a nonce option in the received PA-Initiation message, the PA-Server message MUST be attached with a nonce option so as to send the nonce value back. The nonce will then be used by the PCP client to check the freshness of this message. From now on, every PCP message within this session will be attached with this session identifier. When receiving a PA message from an unknown session, a PCP device MUST discard the message silently. If the PCP client intends to simplify the authentication process, it MAY append an EAP Identity Response message within the PA-Initiation message so as to inform the PCP server that it would like to perform EAP authentication and skip the step of waiting for the EAP Identity Request.



3.1.2. Authentication triggered by the server

In the scenario where a PCP server receives a common PCP request message from a PCP client which needs to be authenticated, the PCP server can reply with a PA-Server message to initiate a PA session. The result code field of this PA-Server message is set to AUTHENTICATION-REQUIRED. In addition, the PCP server MUST assign a session ID for the session and transfer it within the PA-Server message. The Sequence Number field in the PA-Server is set as 0. In the PA messages exchanged afterwards in this session, the session ID

will be used in order to help session partners distinguish the messages within this session from those not within. When the PCP client receives this initial PA-Server message from the PCP server, it can reply with a PA-Client message or silently discard the request message according to its local policies. In the PA-Client message, a nonce option which consists of a random nonce MAY be appended. If so, in the next PA-Server message, the PCP server MUST forward the nonce back within a nonce option.



3.1.3. Authentication using EAP

In a PA session, an EAP request message is transported within a PA-Server message, and an EAP response message is transported within a PA-Client message. EAP relies on the underlying protocol to provide reliable transmission; any reordered delivery or loss of packets occurred during transportation must be detected and addressed. Therefore, after sending out a PA-Server message, the PCP server will not send a new PA-Server message until it receives a PA-Client message with a proper sequence number from the PCP client, and vice versa. If a PCP device receives a PA message from its partner and cannot generate an EAP response immediately due to certain reasons (e.g., waiting for human input to construct a EAP message or waiting for the additional PA messages in order to construct a complete EAP message), the PCP device MUST reply with a PA-Acknowledgement message (PA message with a Received Packet Option) to indicate that the message has been received. This approach not only can avoid unnecessary retransmission of the PA message but also can guarantee the reliable message delivery in the conditions where a PCP device needs to receive multiple PA messages before generating an EAP response.

In this approach, it is mandated for a PCP client and a PCP server to perform a key-generating EAP method in authentication. Particularly, a PCP authentication implementation MUST support EAP-TTLS [RFC5281]

and SHOULD support TEAP [RFC7170]. Therefore, after a successful authentication procedure, a Master Session Key (MSK) will be generated. If the PCP client and the PCP server want to generate a transport key using the MSK, they need to agree upon a Pseudo-Random Function (PRF) for the transport key derivation and a MAC algorithm to provide data origin authentication for subsequent PCP messages. In order to do this, the PCP server needs to append a set of PRF Options and MAC Algorithm Options to the initial PA-Server message. Each PRF Option contains a PRF that the PCP server supports, and each MAC Algorithm Option contains a MAC (Message Authentication Code) algorithm that the PCP server supports. Moreover, in the first PA-Server message, the server MAY also attach an ID Indicator Option defined in Section 5.11 to direct the client to choose correct credentials. After receiving the options, the PCP client selects the PRF and the MAC algorithm which it would like to use, and then adds the associated PRF and MAC Algorithm Options to the next PA-Client message.

After the EAP authentication, the PCP server sends out a PA-Server message to indicate the EAP authentication and PCP authorization results. If the EAP authentication succeeds, the result code of the PA-Server message is AUTHENTICATION-SUCCEEDED. In this case, before sending out the PA-Server message, the PCP server MUST generate a PCP SA and use the derived transport key to generate a digest for the message. The digest is transported within an Authentication Tag Option for PCP Auth. A more detailed description of generating the authentication data can be found in Section 6.1. In addition, the PA-Server MAY also contain a Session Lifetime Option defined in Section 5.9 which indicates the lifetime of the PA session (i.e., the lifetime of the MSK). After receiving the PA-Server message, the PCP client then needs to generate a PA-Client message as response. If the PCP client also authenticates the PCP server, the result code of the PA-Client is AUTHENTICATION-SUCCEEDED. In addition, the PCP client needs to generate a PCP SA and uses the derived transport key to secure the message. From then on, all the PCP messages within the session are secured with the transport key and the MAC algorithm specified in the PCP SA, unless a re-authentication is performed. The first secure PA-client response from the client MUST include the set of PRF and MAC Algorithm options received from the PCP server. The PCP server determines if the set of algorithms conveyed by the client matches the set it had initially sent, to detect an algorithm downgrade attack. If the server detects a downgrade attack then it MUST send a PA-Server message with result code DOWNGRADE-ATTACK-DETECTED and terminate the session.

If a PCP client/server cannot authenticate its session partner, the device sends out a PA message with the result code, AUTHENTICATION-FAILED. If the EAP authentication succeeds but authorization fails,

the device making the decision sends out a PA message with the result code, AUTHORIZATION-FAILED. In these two cases, after the PA message is sent out, the PA session MUST be terminated immediately.

3.2. Session Termination

A PA session can be explicitly terminated by sending a termination-indicating PA message (a PA message with a result code "SESSION-TERMINATED") from either session partner. After receiving a Termination-Indicating message from the session partner, a PCP device MUST respond with a Termination-Indicating PA message and remove the PA SA immediately. When the session partner initiating the termination process receives the PA message, it will remove the associated PA SA immediately.

3.3. Session Re-Authentication

A session partner may select to perform EAP re-authentication if it would like to update the PCP SA without initiating a new PA session. An re-authentication procedure could be triggered for the following reasons:

- The session lifetime needs to be extended.

- The sequence number is going to reach the maximum value. Specifically, when the sequence number reaches 2**32 - 2**16, the session partner MUST trigger re-authentication.

When the PCP server would like to initiate a re-authentication, it sends the PCP client a PA-Server message. The result code of the message is set to "RE-AUTHENTICATION", which indicates the message is for a re-authentication process. If the PCP client would like to start the re-authentication, it will send a PA-Client message to the PCP server, with the result code of the PA-Client message set to "RE-AUTHENTICATION". Then, the session partners exchange PA messages to transfer EAP messages for the re-authentication. During the re-authentication procedure, the session partners protect the integrity of PA messages with the key and MAC algorithm specified in the current PCP SA; the sequence numbers associated with the message will continue to keep increasing according to Section 6.3.

If the EAP re-authentication succeeds, the result code of the last PA-Server is "AUTHENTICATION-SUCCEEDED". In this case, before sending out the PA-Server message, the PCP server MUST update the SA and use the new key to generate a digest for the PA-Server and subsequent PCP messages. In addition, the PA-Server message MAY be appended with a Session Lifetime Option which indicates the new

lifetime of the PA session. PA and PCP message sequence numbers must also be reset to zero.

If the EAP authentication fails, the result code of the last PA-Server is "AUTHENTICATION-FAILED". If the EAP authentication succeeds but authorization fails, the result code of the last PA-Server is "AUTHORIZATION-FAILED". In the latter two cases, the PA session MUST be terminated immediately after the last PA message exchange.

During re-authentication, the session partners can also exchange common PCP messages in parallel. The common PCP messages MUST be protected with the current SA until the new SA has been generated.

4. PA Security Association

At the beginning of a PA session, a session SHOULD generate a PA SA to maintain its state information during the session. The parameters of a PA SA are listed as follows:

- IP address and UDP port number of the PCP client
- IP address and UDP port number of the PCP server
- Session Identifier
- Sequence number for the next outgoing PA message
- Sequence number for the next incoming PA message
- Sequence number for the next outgoing common PCP message
- Sequence number for the next incoming common PCP message
- Last outgoing message payload
- Retransmission interval
- MSK: The master session key generated by the EAP method.
- MAC algorithm: The algorithm that the transport key should use to generate digests for PCP messages.
- Pseudo-random function: The pseudo random function negotiated in the initial PA-Server and PA-Client exchange for the transport key derivation

- Transport key: the key derived from the MSK to provide integrity protection and data origin authentication for the messages in the PA session. The lifetime of the transport key SHOULD be identical to the lifetime of the session.

- The nonce selected by the PCP client at the initiation of the session.

- Key ID: the ID associated with Transport key.

Particularly, the transport key is computed in the following way: Transport key = prf(MSK, "IETF PCP" || Session_ID || Nonce || key ID), where:

- prf: The pseudo-random function assigned in the Pseudo-random function parameter.

- MSK: The master session key generated by the EAP method.

- "IETF PCP": The ASCII code representation of the non-NULL terminated string (excluding the double quotes around it).

- '||' : is the concatenation operator.

- Session_ID: The ID of the session which the MSK is derived from.

- Nonce: The nonce selected by the client and transported in the Initial PA-Client message. If the PCP client does not select one, this value is set as 0.

- Key ID: The ID assigned for the transport key.

5. Packet Format

5.1. Packet Format of PCP Auth Messages

The format of the PA-Server message is identical to the response message format specified in Section 7.2 of [RFC6887].

As illustrated in Figure 1, the PA-Client messages use the request header specified in Section 7.1 of[RFC6887]. The only difference is that eight reserved bits are used to transfer the result codes (e.g., "INITIATION", "AUTHENTICATION-FAILED"). Other fields in Figure 1 are described in Section 7.1 of [RFC6887].

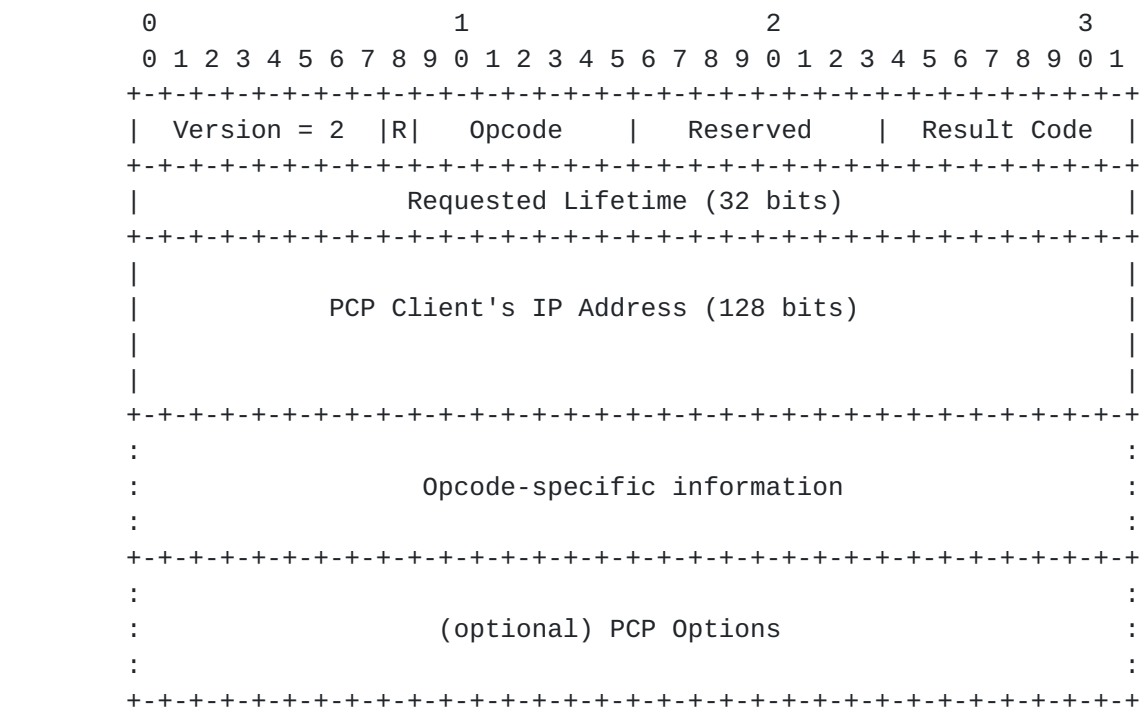
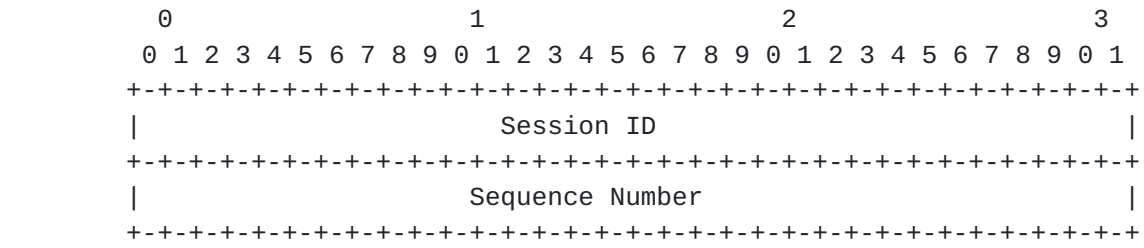


Figure 1. PA-Client message Format

5.2. Authentication Opcode

The following figure illustrates the format of an authentication Opcode:

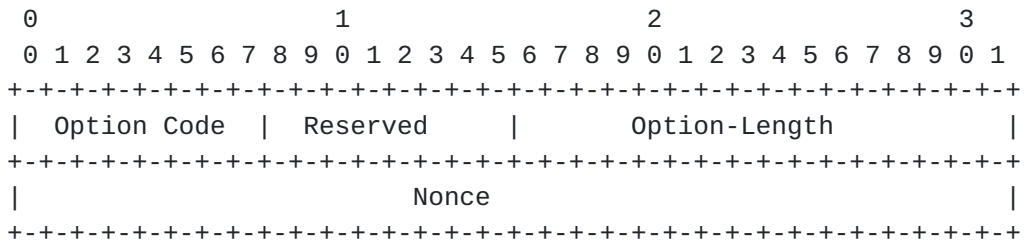


Session ID: This field contains a 32-bit PA session identifier.

Sequence Number: This field contains a 32-bit sequence number. In this solution, a sequence number needs to be incremented on every new (non-retransmission) outgoing message in order to provide an ordering guarantee for PCP messages.

5.3. Nonce Option

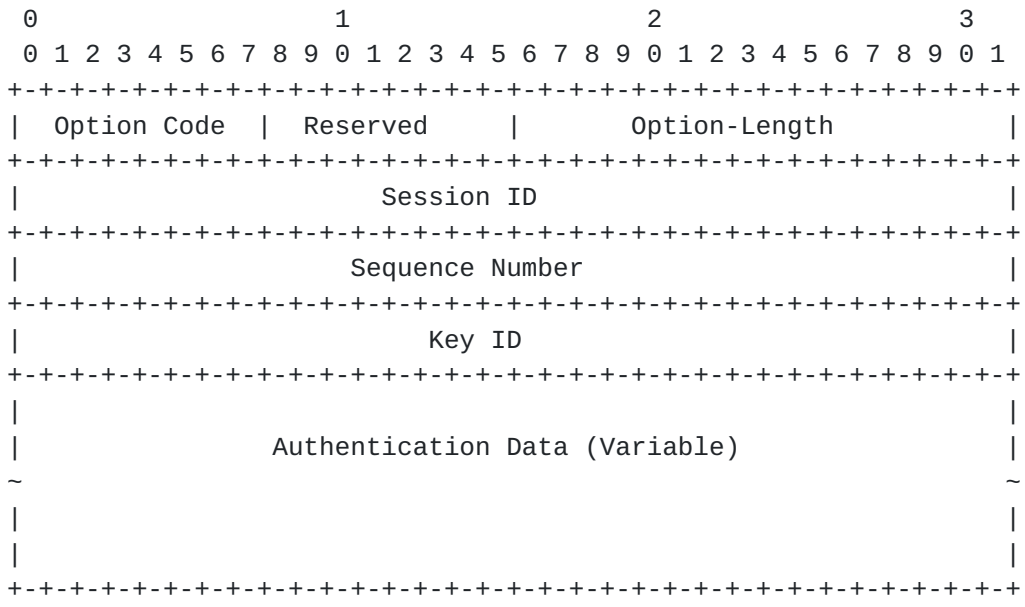
Because the session identifier of PA session is determined by the PCP server, a PCP client does not know the session identifier which will be used when it sends out a PA-Initiation message. In order to prevent an attacker from interrupting the authentication process by sending off-line generated PA-Server messages, the PCP client needs to generate a random number as a nonce in the PA-Initiation message. The PCP server will append the nonce within the initial PA-Server message. If the PA-Server message does not carry the correct nonce, the message will be discarded silently.



Option-Length: The length of the Nonce Option (in octet), including the 4 octet fixed header and the variable length of the authentication data.

Nonce: A random 32 bit number which is transported within a PA-Initiation message and the corresponding reply message from the PCP server.

5.4. Authentication Tag Option for Common PCP message



Because there is no authentication Opcode in common PCP message, the authentication tag for common PCP messages needs to carry the session ID and sequence number.

Option-Length: The length of the Authentication Tag Option for Common PCP (in octets), including the 12 octet fixed header and the variable length of the authentication data.

Session ID: A 32-bit field used to identify the the session to which the message belongs and identify the secret key used to create the message digest appended to the PCP message.

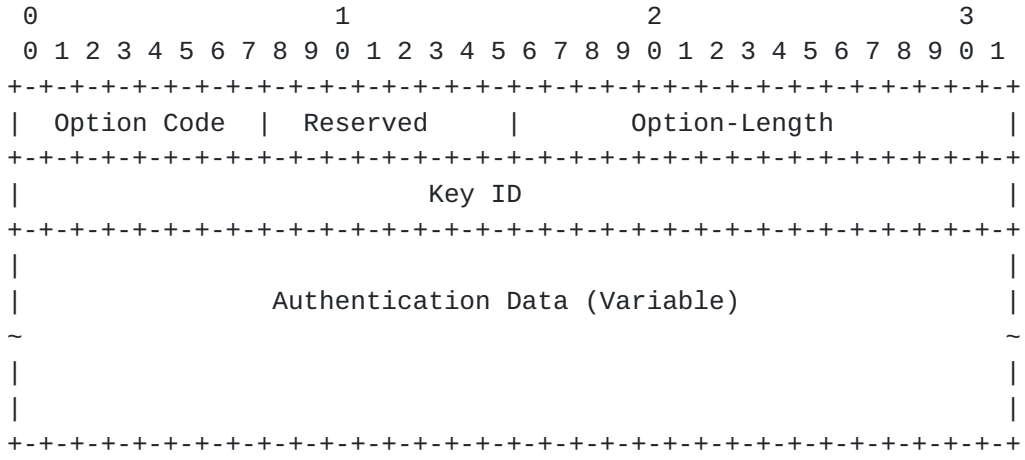
Sequence Number: A 32-bit sequence number. In this solution, a sequence number needs to be incremented on every new (non-retransmission) outgoing message in order to provide ordering guarantee for common PCP messages.

Key ID: The ID associated with the transport key used to generate authentication data. This field is filled with zero if the MSK is directly used to secure the message.

Authentication Data: A variable-length field that carries the Message Authentication Code for the PCP message. The generation of the digest varies according to the algorithms specified in different PCP SAs. This field MUST end on a 32-bit boundary, padded with 0's when necessary.

5.5. Authentication Tag Option for PA Messages

This option is used to provide message authentication for PA messages. Compared with the Authentication Tag Option for Common PCP, the session ID field and the sequence number field are removed because such information is provided in the Authentication Opcode.

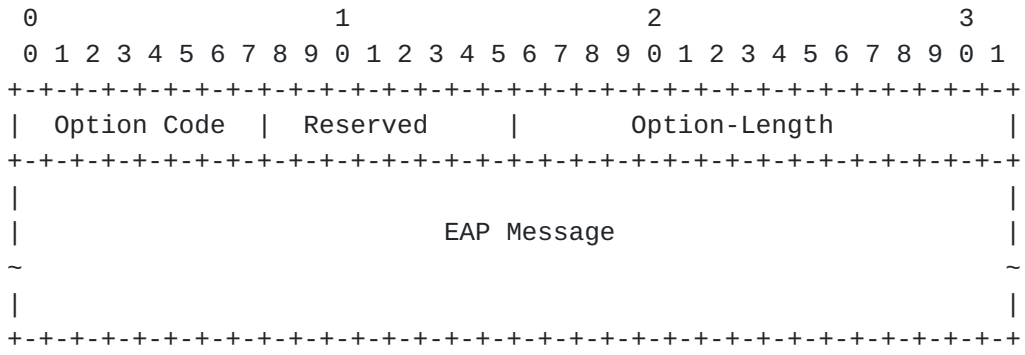


Option-Length: The length of the Authentication Tag Option for PCP Auth (in octet), including the 12 octet fixed header and the variable length of the authentication data.

Key ID: The ID associated with the transport key used to generate authentication data. This field is filled with zero if MSK is directly used to secure the message.

Authentication Data: A variable-length field that carries the Message Authentication Code for the PCP message. The generation of the digest varies according to the algorithms specified in different PCP SAs. This field MUST end on a 32-bit boundary, padded with null characters when necessary.

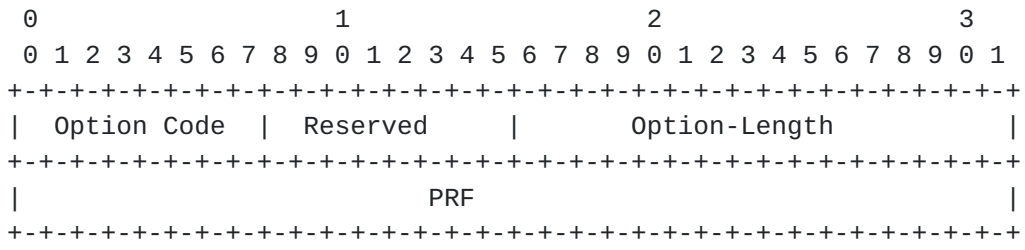
5.6. EAP Payload Option



Option-Length: The length of the EAP Payload Option (in octet), including the 4 octet fixed header and the variable length of the EAP message.

EAP Message: The EAP message transferred. Note this field MUST end on a 32-bit boundary, padded with 0's when necessary.

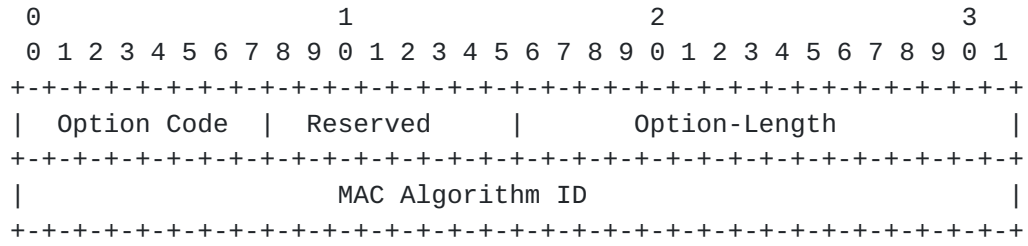
5.7. PRF Option



Option-Length: The length of the PRF Option (in octet), including the 4 octet fixed header and the variable length of the EAP message.

PRF: The Pseudo-Random Function which the sender supports to generate an MSK. This field contains an IKEv2 Transform ID of Transform Type 2 [RFC4306][RFC4868]. A PCP implementation MUST support PRF_HMAC_SHA2_256 (5).

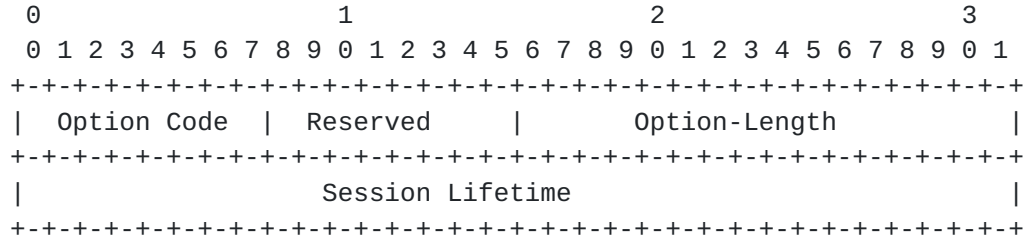
5.8. MAC Algorithm Option



Option-Length: The length of the MAC Algorithm Option (in octet), including the 4 octet fixed header and the variable length of the EAP message.

MAC Algorithm ID: Indicate the MAC algorithm which the sender supports to generate authentication data. The MAC Algorithm ID field contains an IKEv2 Transform ID of Transform Type 3 [RFC4306][RFC4868]. A PCP implementation MUST support AUTH_HMAC_SHA2_256_128 (12).

5.9. Session Lifetime Option

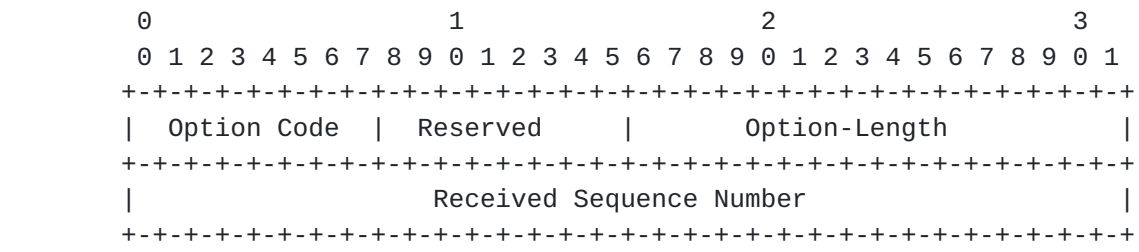


Option-Length: The length of the Session Lifetime Option (in octets), including the 4 octet fixed header and the variable length of the EAP message.

Session Lifetime: The lifetime of the PA Session, which is decided by the authorization result.

5.10. Received Packet Option

This option is used in a PA-Acknowledgement message to indicate that a message with the contained sequence number has been received.

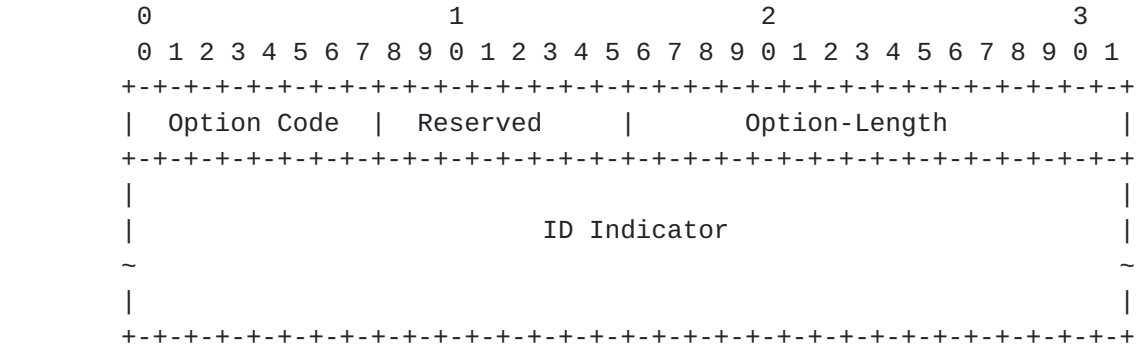


Option-Length: The length of the Received Packet Option (in octet), including the 4 octet fixed header and the variable length of the EAP message.

Received Sequence Number: The sequence number of the last received PCP message.

5.11. ID Indicator Option

The ID Indicator option is used by the PCP client to determine which credentials to provide to the PCP server.



Option-Length: The length of the ID Indicator Option (in octet), including the 4 octet fixed header and the variable length of the EAP message.

ID Indicator: The identity of the authority that issued the credentials. The field MUST end on a 32-bit boundary, padded with 0's when necessary. The ID indicator field is UTF-8 encoded [RFC3629] Unicode code point conforming to the "UsernameCaseMapped" profile of the PRECIS IdentifierClass [I-D.ietf-precis-saslprepbis]. PCP client validates that the ID indicator field conforms to the "UsernameCaseMapped" profile of the PRECIS IdentifierClass. PCP client enforces the rules specified in section 3.2.2 of [I-D.ietf-precis-saslprepbis] to map the ID indicator field. PCP client compares the resulting string with the ID indicators stored locally on the PCP client to pick the credentials for authentication. The two indicator strings are

to be considered equivalent by the client if they are an exact octet-for-octet match.

6. Processing Rules

6.1. Authentication Data Generation

If a PCP SA is generated as the result of a successful EAP authentication process, every subsequent PCP message within the session MUST carry an Authentication Tag Option which contains the digest of the PCP message for data origin authentication and integrity protection.

- Before generating a digest for a PA message, a device needs to first locate the PCP SA according to the session identifier and then get the transport key. Then the device appends an Authentication Tag Option for PCP Auth at the end of the PCP Auth message. The length of the Authentication Data field is decided by the MAC algorithm adopted in the session. The device then fills the Key ID field with the key ID of the transport key, and sets the Authentication Data field to 0. After this, the device generates a digest for the entire PCP message (including the PCP header and Authentication Tag Option) using the transport key and the associated MAC algorithm, and inserts the generated digest into the Authentication Data field.

- Similar to generating a digest for a PA message, before generating a digest for a common PCP message, a device needs to first locate the PCP SA according to the session identifier and then get the transport key. Then the device appends the Authentication Tag Option at the end of common PCP message. The length of the Authentication Data field is decided by the MAC algorithm adopted in the session. The device then uses the corresponding values derived from the SA to fill the Session ID field, the Sequence Number field, and the Key ID field, and sets the Authentication Data field to 0. After this, the device generates a digest for the entire PCP message (including the PCP header and Authentication Tag Option) using the transport key and the associated MAC algorithm, and inputs the generated digest into the Authentication Data field.

6.2. Authentication Data Validation

When a device receives a common PCP message with an Authentication Tag Option for Common PCP, the device needs to use the session ID transported in the option to locate the proper SA, and then find the associated transport key (using the key ID in the option) and the MAC algorithm. If no proper SA or transport key is found or the sequence

number is invalid (see Section 6.5), the PCP message MUST be discarded silently. After storing the value of the Authentication field of the Authentication Tag Option, the device fills the Authentication field with zeros. Then, the device generates a digest for the message (including the PCP header and Authentication Tag Option) with the transport key and the MAC algorithm. If the value of the newly generated digest is identical to the stored one, the device can ensure that the message has not been tampered with, and the validation succeeds. Otherwise, the message MUST be discarded.

Similarly, when a device receives a PA message with an Authentication Tag Option for PCP Authentication, the device needs to use the session ID transported in the opcode to locate the proper SA, and then find the associated transport key (using the key ID in the option) and the MAC algorithm. If no proper SA or transport key is found or the sequence number is invalid (see Section 6.4), the PCP message MUST be discarded silently. After storing the value of the Authentication field of the Authentication Tag Option, the device fills the Authentication field with zeros. Then, the device generates a digest for the message (including the PCP header and Authentication Tag Option) with the transport key and the MAC algorithm. If the value of the newly generated digest is identical to the stored one, the device can ensure that the message has not been tampered with, and the validation succeeds. Otherwise, the message MUST be discarded.

6.3. Retransmission Policies for PA Messages

Because EAP relies on the underlying protocols to provide reliable transmission, after sending a PA message, a PCP client/server MUST NOT send out any subsequent messages until receiving a PA message with a proper sequence number from the peer. If no such a message is received the PCP device will re-send the last message according to retransmission policies. This work reuses the retransmission policies specified in the base PCP protocol (Section 8.1.1 of [RFC6887]). In the base PCP protocol, such retransmission policies are only applied by PCP clients. However, in this work, such retransmission policies are also applied by the PCP servers. If Maximum retransmission duration seconds have elapsed and no expected response is received, the device will terminate the session and discard the current SA.

As illustrated in Section 3.1.3, in order to avoid unnecessary re-transmission, the device receiving a PA message MUST send a PA-Acknowledgement message to the sender of the PA message when it cannot send a PA response immediately. The PA-Acknowledgement message is used to indicate the receipt of the PA message. When the

sender receives the PA-Acknowledgement message, it will stop the retransmission.

Note that the last PA messages transported within the phases of session initiation, session re-authentication, and session termination do not have to follow the above policies since the devices sending out those messages do not expect any further PA messages.

When a device receives a re-transmitted last incoming PA message from its session partner, it MUST try to answer it by sending the last outgoing PA message again. However, if the duplicate message has the same sequence number but is not bit-wise identical to the original message then the device MUST discard it. In order to achieve this function, the device may need to maintain the last incoming and the associated outgoing messages. In this case, if no outgoing PA message has been generated for the received duplicate PA message yet, the device needs to send a PA-Acknowledgement message. The rate of replying to duplicate PA messages MUST be limited to provide robustness against denial of service (DoS) attacks. The details of rate limiting are outside the scope of this specification.

6.4. Sequence Numbers for PCP Auth Messages

PCP uses UDP to transport signaling messages. As an un-reliable transport protocol, UDP does not guarantee ordered packet delivery and does not provide any protection from packet loss. In order to ensure the EAP messages are exchanged in a reliable way, every PCP message exchanged during EAP authentication must carry an monotonically increasing sequence number. During a PA session, a PCP device needs to maintain two sequence numbers for PA messages, one for incoming PA messages and one for outgoing PA messages. When generating an outgoing PA message, the device adds the associated outgoing sequence number to the message and increments the sequence number maintained in the SA by 1. When receiving a PA message from its session partner, the device will not accept it if the sequence number carried in the message does not match the incoming sequence number the device maintains. After confirming that the received message is valid, the device increments the incoming sequence number maintained in the SA by 1.

The above rules are not applicable to PA-Acknowledgement messages (i.e., PA messages containing a Received Packet Option). A PA-Acknowledgement message does not transport any EAP message and only indicates that a PA message is received. Therefore, reliable transmission of PA-Acknowledgement message is not required. For instance, after sending out a PA-Acknowledgement message, a device generates an EAP response. In this case, the device need not have to

confirm whether the PA-Acknowledgement message has been received by its session partner or not. Therefore, when receiving or sending out a PA-Acknowledgement message, the device MUST NOT increase the corresponding sequence number stored in the SA. Otherwise, loss of a PA-Acknowledgement message will cause a mismatch in sequence numbers.

Another exception is the message retransmission scenario. As discussed in Section 6.3, when a PCP device does not receive any response from its session partner it needs to retransmit the last outgoing PA message following the retransmission procedure specified in section 8.1.1 of [RFC6887]. The original message and duplicate messages MUST be bit-wise identical. When the device receives such a duplicate PA message from its session partner, it MUST send the last outgoing PA message again. In such cases, the maintained incoming and outgoing sequence numbers will not be affected by the message retransmission.

6.5. Sequence Numbers for Common PCP Messages

When transporting common PCP messages within a PA session, a PCP device needs to maintain a sequence number for outgoing common PCP messages and a sequence number for incoming common PCP messages. When generating a new outgoing PCP message, the PCP device updates the Sequence Number field in the Authentication tag option with the outgoing sequence number maintained in the SA and increments the outgoing sequence number by 1.

When receiving a PCP message from its session partner, the PCP device will not accept it if the sequence number carried in the message is smaller than the incoming sequence number the device maintains. This approach can protect the PCP device from replay attacks. After confirming that the received message is valid, the PCP device will update the incoming sequence number maintained in the PCP SA with the sequence number of the incoming message.

Note that the sequence number in the incoming message may not exactly match the incoming sequence number maintained locally. As discussed in the base PCP specification [RFC6887], if a PCP client is no longer interested in the PCP transaction and has not yet received a PCP response from the server then it will stop retransmitting the PCP request. After that, the PCP client might generate new PCP requests for other purposes using the current SA. In this case, the sequence number in the new request will be larger than the sequence number in the old request and so will be larger than the incoming sequence number maintained in the PCP server.

Note that in the base PCP specification [RFC6887], a PCP client needs to select a nonce in each MAP or PEER request, and the nonce is sent

back in the response. However, it is possible for a client to use the same nonce in multiple MAP or PEER requests, and this may cause a potential risk of replay attacks. This attack is addressed by using the sequence number in the PCP response.

6.6. MTU Considerations

EAP methods are responsible for MTU handling, so no special facilities are required in PCP to deal with MTU issues. Particularly, EAP lower layers indicate to EAP methods and AAA servers the MTU of the lower layer. EAP methods such as EAP-TLS [RFC5216], TEAP [RFC7170], and others that are likely to exceed reasonable MTUs provide support for fragmentation and reassembly. Others, such as EAP-GPSK [RFC5433] assume they will never send packets larger than the MTU and use small EAP packets.

If an EAP message is too long to be transported within a single PA message, it will be divided into multiple sections and sent within different PA messages. Note that the receiver may not be able to know what to do in the next step until it has received all the sections and reconstructed the complete EAP message. In this case, in order to guarantee reliable message transmission, after receiving a PA message, the receiver replies with a PA-Acknowledgement message to notify the sender to send the next PA message.

7. IANA Considerations

In order to identify Authentication Opcode, a new value (TBD) needs to be defined in the IANA registry for PCP Opcodes.

A set of options are defined in this specification. Each of them needs to be associated with a value defined in the IANA registry for PCP option code:

Nonce Option TBD

Authentication Tag Option for Common PCP messages TBD

Authentication Tag Option for PCP Auth messages TBD

EAP Payload Option TBD

PRF Option TBD

MAC Algorithm Option TBD

Session Lifetime Option TBD

Received Packet Option TBD

ID Indicator Option TBD

A set of new result codes is specified in this specification, each result code needs to assigned a value in the IANA registry for PCP result codes.

TBD INITIATION

TBD AUTHENTICATION-REQUIRED

TBD AUTHENTICATION-FAILED

TBD AUTHENTICATION-SUCCEEDED

TBD AUTHORIZATION-FAILED

TBD SESSION-TERMINATED

TBD DOWNGRADE-ATTACK-DETECTED

8. Security Considerations

In this work, after a successful EAP authentication process is performed between two PCP devices, an MSK will be exported. The MSK will be used to derive the transport keys to generate MAC digests for subsequent PCP message exchanges. However, before a transport key has been generated, the PA messages exchanged within a PA session have little cryptographic protection, and if there is no already established security channel between two session partners, these messages are subject to man-in-the-middle attacks and DOS attacks. For instance, the initial PA-Server and PA-Client exchange is vulnerable to spoofing attacks as these messages are not authenticated and integrity protected. In addition, because the PRF and MAC algorithms are transported at this stage, an attacker may try to remove the PRF and MAC options containing strong algorithms from the initial PA-Server message and force the client choose the weakest algorithms. Therefore, the server needs to guarantee that all the PRF and MAC algorithms it provides support are strong enough.

In order to prevent very basic DOS attacks, a PCP device SHOULD generate state information as little as possible in the initial PA-Server and PA-Client exchanges. The choice of EAP method is also very important. The selected EAP method must be resilient to the attacks possible in an insecure network environment, provide user-identity confidentiality, protection against dictionary attacks, and support session-key establishment.

When a PCP proxy is located between a PCP server and PCP clients, the proxy may perform authentication with the PCP server before it processes requests from the clients. In addition, re-authentication between the PCP proxy and PCP server will not interrupt the service that the proxy provides to the clients since the proxy is still allowed to send common PCP messages to the PCP server during that period.

9. Acknowledgements

Thanks to Dan Wing, Prashanth Patil, Dave Thaler and Peter Saint-Andre for the valuable comments.

10. Change Log

[Note: This section should be removed by the RFC Editor upon publication]

10.1. Changes from wasserman-pcp-authentication-02 to ietf-pcp-authentication-00

- Added discussion of in-band and out-of-band key management options, leaving choice open for later WG decision.
- Removed support for fragmenting EAP messages, as that is handled by EAP methods.

10.2. Changes from wasserman-pcp-authentication-01 to -02

- Add a nonce into the first two exchanged PCP-Auth message between the PCP client and PCP server. When a PCP client initiate the session, it can use the nonce to detect offline attacks.
- Add the key ID field into the authentication tag option so that a MSK can generate multiple transport keys.
- Specify that when a PCP device receives a PCP-Auth-Server or a PCP-Auth-Client message from its partner the PCP device needs to reply with a PCP-Auth-Acknowledge message to indicate that the message has been received.
- Add the support of fragmenting EAP messages.

10.3. Changes from ietf-pcp-authentication-00 to -01

- Editorial changes, added use cases to introduction.

10.4. Changes from ietf-pcp-authentication-01 to -02

- Add the support of re-authentication initiated by PCP server.
- Specify that when a PCP device receives a PCP-Auth-Server or a PCP-Auth-Client message from its partner the PCP device MAY reply with a PCP-Auth-Acknowledge message to indicate that the message has been received.
- Discuss the format of the PCP-Auth-Acknowledge message.
- Remove the redundant information from the Auth Opcode, and specify new result codes transported in PCP packet headers
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10.5. Changes from ietf-pcp-authentication-02 to -03

- Change the name "PCP-Auth-Request" to "PCP-Auth-Server"
- Change the name "PCP-Auth-Response" to "PCP-Auth-Client"
- Specify two new sequence numbers for common PCP messages in the PCP SA, and describe how to use them
- Specify a Authentication Tag Option for PCP Common Messages
- Introduce the scenario where a EAP message has to be divided into multiple sections and transported in different PCP-Auth messages (for the reasons of MTU), and introduce how to use PCP-Auth-Acknowledge messages to ensure reliable packet delivery in this case.

10.6. Changes from ietf-pcp-authentication-03 to -04

- Change the name "PCP-Auth" to "PA".
- Refine the retransmission policies.
- Add more discussion about the sequence number management .
- Provide the discussion about how to instruct a PCP client to choose proper credential during authentication, and an ID Indicator Option is defined for that purpose.

10.7. Changes from ietf-pcp-authentication-04 to -05

- Add contents in IANA considerations.
- Add discussions in fragmentation.
- Refine the PA messages retransmission policies.
- Add IANA considerations.

10.8. Changes from ietf-pcp-authentication-05 to -06

- Added mechanism to handle algorithm downgrade attack.
- Updated Security Considerations section.
- Updated ID Indicator Option.

11. References

11.1. Normative References

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