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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 communications 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 proposes 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.

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1. Introduction

Using the Port Control Protocol (PCP) [RFC6887], an IPv4 or IPv6 host 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 packets during transportation.

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

- o Loss of EAP messages during transportation
- o Disordered delivery of EAP messages
- o Generation of transport keys
- o Integrity protection and data origin authentication for PCP messages
- o 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::

- o On security infrastructure equipment, such as corporate firewalls, that does not create implicit mappings.
- o 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.
- o For any implementation that wants to be more permissive in authorizing explicit mappings than it is in authorizing implicit mappings.

- o For implementations that support the THIRD_PARTY Option (unless they can meet the constraints outlined in Section 14.1.2.2).
- o For implementations that wish to support any deployment scenario that does not meet the constraints described in Section 14.1.

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 device (e.g., a host) 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 device (e.g., a NAT or a firewall) that implements the server-side of the PCP protocol, via which PCP clients request and manage explicit mappings. 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 (PCP-Auth) Session: A series of PCP message exchanges transferred between a PCP client and a PCP server. The PCP message involved within a session includes the PCP-Auth messages used to perform EAP authentication, key distribution and session management, and the common PCP messages secured with the keys distributed during authentication. Each PCP-Auth session is assigned a distinctive Session ID.

Session Partner: A PCP device involved within a PCP-Auth session. Each PCP-Auth session has two session partners (a PCP server and a PCP client).

Session Lifetime: The life period associated with a PCP-Auth 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 PCP-Auth session, using an EAP key generating method (e.g., the one defined in [RFC5448]).

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

Common PCP message: A PCP message which does not contain an Authentication OpCode. This document specifies an option, the Authentication Tag Option for Common PCP, 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 PCP-Auth session, a PCP client and a PCP server need to exchange a series of PCP-Auth messages in order to perform an EAP authentication process. Each PCP-Auth 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 managements). The Authentication OpCode consists of two fields: Session ID and Sequence Number. The Session ID field is used to identify the session to which the message belongs. The sequence number field is used to detect the disorder or the duplication occurred during packet delivery.

When a PCP client intends to proactively initiate a PCP-Auth session with a PCP server, it sends a PCP-Auth-Initiation message (a PCP-Auth-Client message with the result code "INITIATION") to the PCP server. In the message, the Session ID and Sequence Number fields of the Authentication OpCode are set as 0. The PCP client MAY also optionally append a nonce option which consists of a random nonce with the message.

After receiving the PCP-Auth-Initiation, if the PCP server agrees to initiate a PCP-Auth session with the PCP client, it will reply with a PCP-Auth-Server message which contains an EAP Identity Request, and the result code field of this PCP-Auth-Server message is set as AUTHENTICATION-REQUIRED. In addition, the server MUST assign a

session identifier which can distinctly identify this session, and fill the identifier into the Session ID field of the Authentication OpCode in the PCP-Auth-Server message. The Sequence Number field of the Authentication OpCode is set as 0. If there is a nonce option in the received PCP-Auth-Initiation message, the PCP-Auth-Server 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 the PCP-Auth-Server message. From now on, every PCP message within this session will be attached with this session identifier. When receiving a PCP-Auth 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 PCP-Auth-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.

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 PCP-Auth-Server message to initiate a PCP-Auth session. The result code field of this PCP-Auth-Server message is set as AUTHENTICATION-REQUIRED. In addition, the PCP server MUST assign a session ID for the session and transfer it within the PCP-Auth-Server message. The Sequence Number field in the PCP-Auth-Server is set as 0. In the PCP-Auth messages exchanged afterwards in this session, the session ID MUST 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 PCP-Auth-Server message from the PCP server, it can reply with a PCP-Auth-Client message or silently discard the request message according to its local policies. In the PCP-Auth-Client message, a nonce option which consists of a random nonce MAY be appended. If so, in the next PCP-Auth-Server message, the PCP sever MUST forward the nonce back within a nonce option.

In a PCP-Auth session, an EAP request message is transported within a PCP-Auth-Server message, and an EAP answer message is transported within a PCP-Auth-Client message. EAP relies on the underlying protocol to provide reliable transmission; any disordered delivery or loss of packets occurred during transportation must be detected and addressed. Therefore, after sending out a PCP-Auth-Server message, the PCP server will not send a new PCP-Auth-Server message until it receives a PCP-Auth-Client message with a proper sequence number from the PCP client, and vice versa. If a PCP device receives a PCP-Auth message from its partner and cannot generate a EAP response within a pre-specified period due to certain reasons (e.g., waiting for human input to construct a EAP message or waiting for the additional PCP-Auth messages in order to construct a complete EAP message), the PCP

device MUST reply with a PCP-Auth-Acknowledge message (PCP-Auth messages with a Received Packet Option) to notify the packet has been received. This approach not only can avoid un-necessarily retransmission of the PCP-Auth message but also can guarantee the reliable packet delivery in the conditions where a PCP device needs to receive multiple PCP-Auth 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. 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 traffic 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 packets. In order to do this, the PCP server needs to append a set of PRF Options and MAC Algorithm Options to the initial PCP-Auth-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. After receiving the options, the PCP client selects the PRF and the MAC algorithm which it would like to use, and then attach the associated PRF and MAC Algorithm Options to the next PCP-Auth-Client message.

After the EAP authentication, the PCP server sends out a PCP-Auth-Server message to indicate the EAP authentication and PCP authorization results. If the EAP authentication succeeds, the result code of the PCP-Auth-Server message is AUTHENTICATION-SUCCEED. In this case, before sending out the PCP-Auth-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 7.1. In addition, the PCP-Auth-Server MAY also contain a Session Lifetime Option which indicates the life-time of the PCP-Auth session (i.e., the life-time of the MSK). After receiving the PCP-Auth-Server message, the PCP client then needs to generate a PCP-Auth-Client message as response. If the PCP client also authenticates the PCP server, the result code of the PCP-Auth-Client is AUTHENTICATION-SUCCEED. In addition, the PCP client needs to generate a PCP SA and uses the derived traffic key to secure the message. From then on, all the PCP messages within the session are secured with the traffic key and the MAC algorithm specified in the PCP SA, unless a re-authentication is performed.

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

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

3.2. Session Termination

A PCP-Auth session can be explicitly terminated by sending a termination-indicating PCP-Auth message (a PCP-Auth message with a result code "SESSION-TERMINATION") from either session partner. After receiving a Termination-Indicating message from the session partner, a PCP device MUST respond with a Termination-Indicating PCP-Auth message and remove the PCP-Auth SA immediately. When the session partner initiating the termination process receives the PCP-Auth message, it will remove the associated PCP-Auth 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 (e.g., update the MSK and rollback the sequence numbers, or extend the session life period) without initiating a new PCP-Auth session.

When the PCP server would like to initiate a re-authentication, it sends the PCP client a PCP-Auth-Server message. The result code of the message is set to "RE-AUTHENTICATION", which indicates the message is for an re-authentication process. If the PCP client would like to start the re-authentication, it will send an PCP-Auth-Client message to the PCP server, the result code of the PCP-Auth-Client message is set to "RE-AUTHENTICATION". Then, the session partners exchange PCP-Auth messages to transfer EAP messages for the re-authentication. During the re-authentication procedure, the session partners protect the integrity of PCP-Auth messages with the key and MAC algorithm specified in the current PCP SA; the sequence numbers associated with the packet will never be rolled back and keep increasing according to Section 7.3.

If the EAP re-authentication succeeds, the result code of the last PCP-Auth-Server is "AUTHENTICATION-SUCCEED". In this case, before sending out the PCP-Auth-Server, the PCP server must update the SA and use the new key to generate digests to protect the integrity and authenticity of the PCP-Auth-Server and any subsequent PCP message. In addition, the PCP-Auth-Server MAY be appended with a Session Lifetime Option which indicates the new life-time of the PCP-Auth session.

If the EAP authentication fails, the result code of the last PCP-Auth-Server is "AUTHENTICATION-FAILED". If the EAP authentication

succeeds but Authorization fails, the result code of the last PCP-Auth-Server is "AUTHORIZATION-FAILED". In the latter two cases, the PCP-Auth session MUST be terminated immediately after the last PCP-Auth message exchange.

4. PA Security Association

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

- o IP address and UDP port number of the PCP client
- o IP address and UDP port number of the PCP server
- o Session Identifier
- o Sequence number for the next outgoing PCP-Auth message
- o Sequence number for the next incoming PCP-Auth message
- o Sequence number for the next outgoing common PCP message (included in the SA for PCP client)
- o Sequence number for the next incoming common PCP message (included in the SA for PCP client)
- o Last outgoing message payload
- o Retransmission interval
- o MSK: The master session key generated by the EAP method.
- o MAC algorithm: The algorithm that the transport key should use to generate digests for PCP messages.
- o Pseudo-random function: The pseudo random function negotiated in the initial PCP-Auth-Server and PCP-Auth-Client exchange for the transport key derivation
- o Transport key: the key derived from the MSK to provide integrity protection and data origin authentication for the messages in the PCP-Auth session. The life-time of the transport key SHOULD be identical to the life-time of the session.
- o The nonce selected by the PCP client at the initiation of the session.

- o 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:

- o The prf: The pseudo-random function assigned in the Pseudo-random function parameter.
- o MSK: The master session key generated by the EAP method.
- o "IETF PCP": The ASCII code representation of the non-NULL terminated string (excluding the double quotes around it).
- o Session_ID: The ID of the session which the MSK is derived from.
- o Nonce: The nonce selected by the client and transported in the Initial PCP-Auth-Client packet. If the PCP client does not select one, this value is set as 0.
- o Key ID: The ID assigned for the traffic key.

5. Result Code

This message use the result code field specified in the PCP headers to transport the information for authentication and session management. Particularly, the values of following result codes are specified.

TBD INITIATION

TBD AUTHENTICATION-REQUIRED

TBD AUTHENTICATION-FAILED

TBD AUTHENTICATION-SUCCEED

TBD AUTHORIZATION-FAILED

TBD SESSION-TERMINATION

6. Packet Format

6.1. Packet Format of PCP Auth Messages

The format of PCP-Auth-Server messages is identical to the response packet format specified in Section 7.2 of [RFC6887].

As illustrated in Figure 1, the PCP-Auth-Client messages use the requester 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].

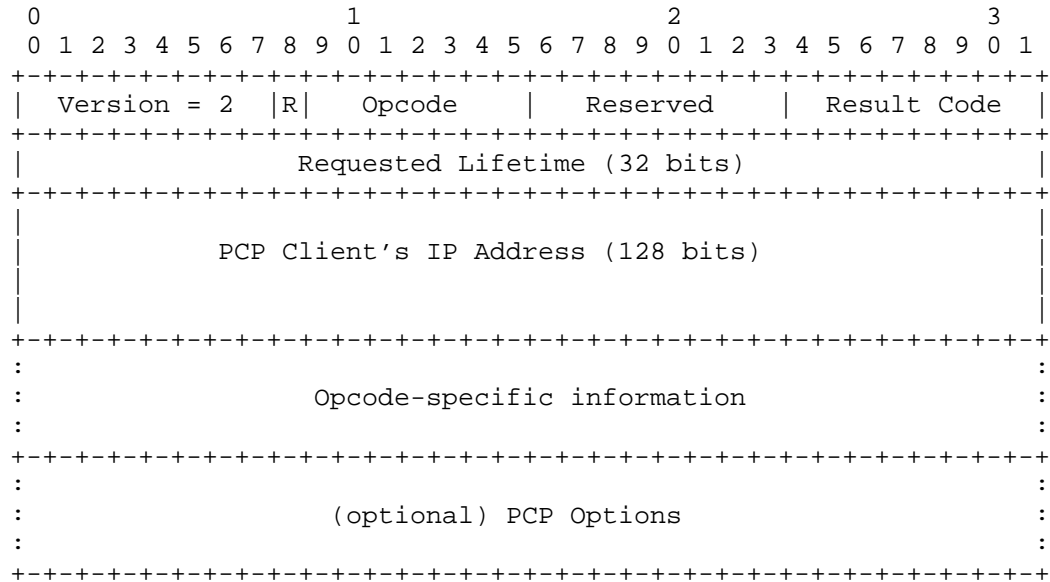
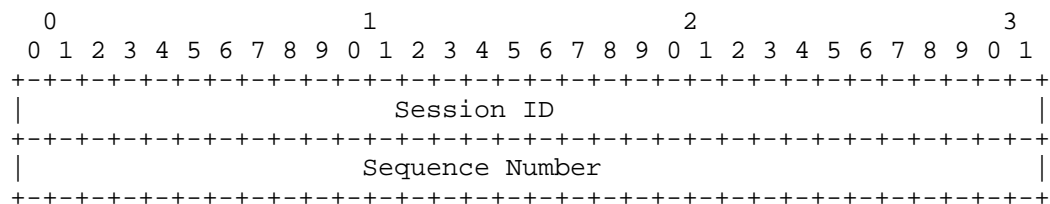


Figure 1. PCP-Auth-Client message Format

6.2. Authentication OpCode

The following figure illustrates the format of an authentication OpCode:



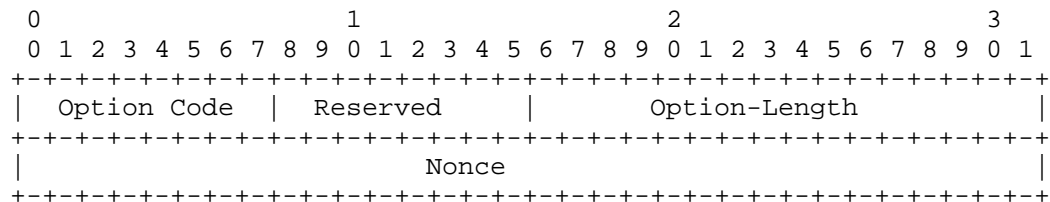
Session ID: This field contains a 32-bit PCP-Auth session identifier.

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 packet in order to provide ordering guarantee for PCP.

6.3. Nonce Option

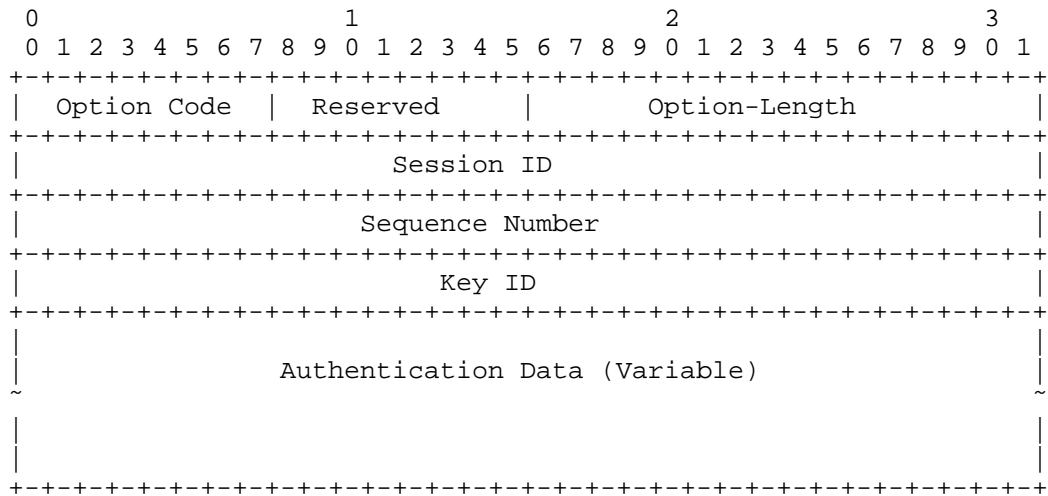
Because the session identifier of PCP-Auth session is determined by the PCP server, a PCP client does not know the session identifier which will be used when it sends out a PCP-Auth-Initiation message. In order to prevent an attacker from interrupting the authentication process by sending off-line generated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

6.4. Authentication Tag Option for Common PCP



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

Session ID: A 32-bit field used to indicates the identifier of the session that the message belongs to and identifies the secret key used to create the message digest appended to the PCP message.

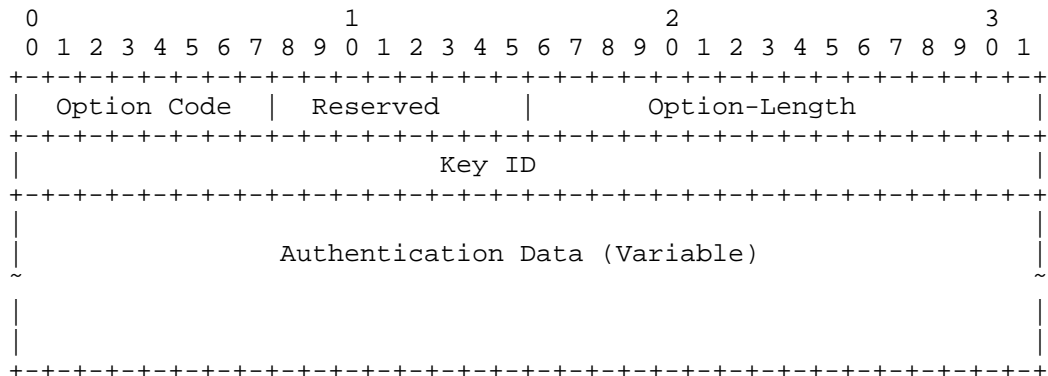
Sequence Number: This field contains a 32-bit sequence number. In this solution, a sequence number needs to be incremented on every new (non-retransmission) outgoing packet in order to provide ordering guarantee for common PCP messages.

Key ID: The ID associated with the traffic 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 packet. The generation of the digest can be various according to the algorithms specified in different PCP SAs. This field MUST end on a 32-bit boundary, padded with 0's when necessary.

6.5. Authentication Tag Option for PCP Auth Messages

This option is used to provide message authentication for PCP-Auth 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.

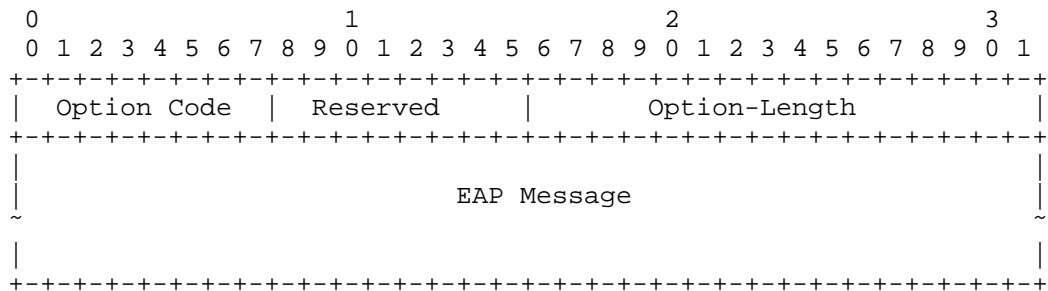


Option-Length: The length of the Authentication Tag Option for PCP Auth (in octet), including the 12 octet fixed header and the variable length of the authentication data.

Key ID: The ID associated with the traffic 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 packet. The generation of the digest can be various according to the algorithms specified in different PCP SAs. This field MUST end on a 32-bit boundary, padded with 0's when necessary.

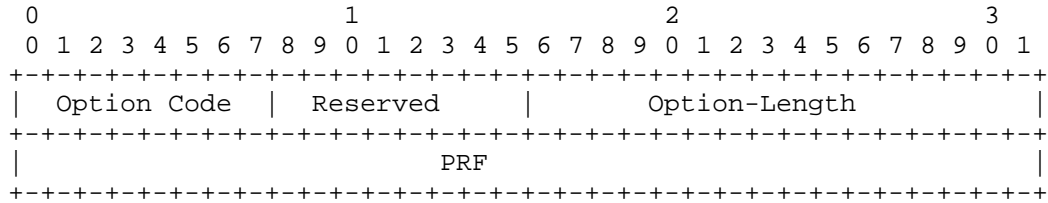
6.6. EAP Payload Option



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.

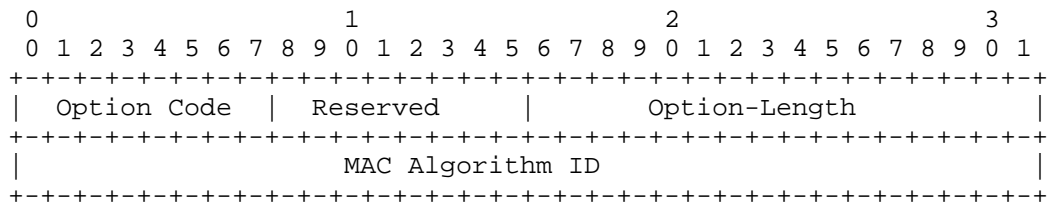
6.7. PRF Option



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).

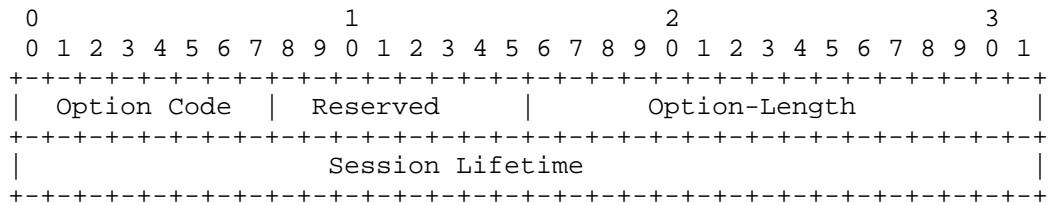
6.8. MAC Algorithm Option



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).

6.9. Session Lifetime Option

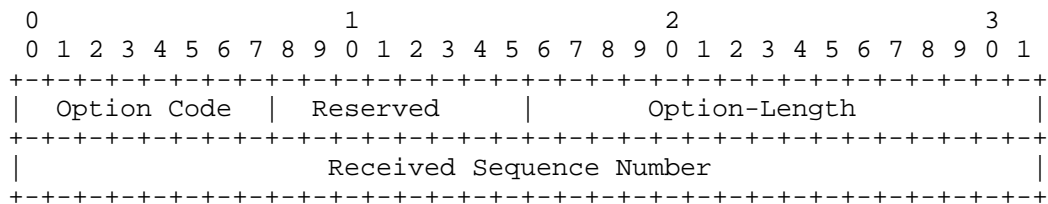


Option-Length: The length of the Session Lifetime Option (in octet), including the 4 octet fixed header and the variable length of the EAP message.

Session Lifetime: The life time of the PCP-Auth Session, which is decided by the authorization result.

6.10. Received Packet Option

This option is used in a PCP-Auth-Acknowledgement message to indicate a packet 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 packet.

7. Processing Rules

7.1. 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 PCP-Auth message, a device needs to first locate the PCP SA according to the session identifier and then get the traffic 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 traffic 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 traffic key and the associated MAC algorithm, and insert the generated digest into the Authentication Data field.

Similar to generating a digest for a PCP-Auth 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 traffic key. Then the device appends the Authentication Tag Option for common PCP at the end of the message. The length of the Authentication Data field is decided by the MAC algorithm adopted in the session. The device then use the corresponding values derived from the SA to fills 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 traffic key and the associated MAC algorithm, and inputs the generated digest into the Authentication Data field.

7.2. Authentication Data Validation

When a device receives a common PCP packet 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 key ID in the option) and the MAC algorithm. If no proper SA or traffic key is found, the PCP packet 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 packet (including the PCP header and Authentication Tag Option) with the transport key and the MAC algorithm found in the first step. If the value of the newly generated digest is identical to the stored one, the device can ensure that the packet has not been tampered with, and the validation succeeds. Otherwise, the packet MUST be discarded.

Similarly, when a device receives a PCP Auth packet with an Authentication Tag Option for PCP Auth, 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 key ID in the option) and the MAC algorithm. If no proper SA or traffic key is found, the PCP packet 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 packet (including the PCP header and Authentication Tag Option) with the transport key and the MAC algorithm found in the first step. If the value of the newly generated digest is identical to the stored one, the device can ensure that the packet has not been tampered with, and the validation succeeds. Otherwise, the packet MUST be discarded.

7.3. Retransmission Policies for PCP Auth Messages

Because EAP relies on the underlying protocols to provide reliable transmission, after sending a PCP-Auth message, a PCP client/server MUST NOT send out any subsequent messages until receiving an expected PCP-Auth message (the PCP-Auth message with a proper sequence number) from the peer. If no such a message is received in a certain period, the PCP device will re-send the last message according to certain 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.

Note that the last PCP-Auth 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 PCP-Auth messages.

When a device receives such a duplicate PCP-Auth message from its session partner, it MUST try to answer it by sending the last outgoing PCP-Auth message again. The rate of replying the duplicate PCP-Auth messages MUST be limited.

7.4. Sequence Numbers for PCP Auth Messages

PCP adopts 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 packet exchanged during EAP authentication must carry a monotonically increasing sequence number. During a PCP-Auth session, a PCP device needs to maintain two sequence numbers for PCP-Auth messages, one for incoming PCP-Auth messages and one for outgoing PCP-Auth messages. When generating an outgoing PCP-Auth packet, the device attaches the associated outgoing sequence number to the packet and increments the sequence number maintained in the SA by 1. When receiving a PCP-Auth packet from its session partner, the device will not accept it if the sequence number carried in the packet does not match the incoming sequence number the device maintains. After confirming that the received packet is valid, the device increments the incoming sequence number maintained in the SA by 1.

The above rules are not applied to PCP-Auth-Acknowledgement messages (i.e., PCP-Auth messages containing a Received Packet Option). A PCP-Auth-Acknowledgement message does not transport any EAP message and only indicate that a PCP-Auth message is received. Therefore, the

reliable transmission of PCP-Auth-Acknowledgement message does not have to be guaranteed. Therefore, when receiving or sending out a PCP-Auth-Acknowledgement message, the device MUST not increase the corresponding sequence number stored in the SA. Otherwise, the lost of a PCP-Auth-Acknowledgement message during transportation will cause the mismatching issues with the sequence numbers.

Another exception is in the message retransmission scenarios. When a device does not receive any response from its session partner in a certain period, it needs to retransmit the last outgoing PCP-Auth message with a limited rate. The duplicate messages and the original message MUST use the identical sequence number. When the device receives such a duplicate PCP-Auth message from its session partner, it MUST try to answer it by sending the last outgoing PCP-Auth message again. Note the rate of replying the duplicate PCP-Auth messages must be limited. In such cases, the maintained incoming and outgoing sequence numbers will not be affected by the message retransmission.

7.5. Sequence Numbers for Common PCP Messages

When transporting common PCP messages within a PCP-Auth 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 messages, the PCP device attaches the outgoing sequence number for common PCP messages to the messages and increments the sequence number maintained in the SA by 1.

When receiving a PCP packet from its session partner, the PCP device will not accept it if the sequence number carried in the packet is smaller than the incoming sequence number the server maintains. This approach can protect the PCP server from replay attacks. After confirming that the received packet is valid, the PCP server will use the sequence number in the incoming packet to take place the incoming sequence number for common PCP messages maintained in the SA.

Note that the sequence number in the incoming packet may not exactly match the incoming sequence number maintained locally. In the base PCP specification [RFC6887], a PCP client may stop retransmitting a PCP request without receiving any expected PCP answer when the client is no longer interested in the PCP transaction. After that, the PCP client will try to generate new PCP requests for other purposes. In this case, the sequence number in the new request will be larger than the incoming sequence number maintained in the PCP server.

7.6. MTU Considerations

EAP methods are responsible for MTU handling, so no special facilities are required in this protocol to deal with MTU issues. If an EAP message is too long for a single PCP-Auth message to transport, it will be divided into multiple sections and transport them within different PCP-Auth messages. Note that the receiver may not be able to know what to do in the next step until receiving all the sections and constructing the complete EAP message. In this case, in order to guarantee reliable message transmission, after receiving a PCP-Auth message, the receiver **MUST** reply with a PCP-Auth-Acknowledgement message until all the sections have been received.

8. IANA Considerations

TBD

9. Security Considerations

This section applies only to the in-band key management mechanism. It will need to be updated if the WG choose to pursue the out-of-band key management mechanism discussed above.

In this work, after a successful EAP authentication process performed between two PCP devices, a MSK will be exported. The MSK can 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 PCP-Auth messages exchanged within a PCP-Auth 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 PCP-Auth-Server and PCP-Auth-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 PCP-Auth-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 PCP-Auth-Server and PCP-Auth-Client exchanges. The choice of EAP method is also very important. The selected EAP method must be resilient to the attacks possibly in an insecure network environment, and the user-identity confidentiality, protection against dictionary attacks, and session-key establishment must be supported.

10. Acknowledgements

11. Change Log

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

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

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

- o 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.
- o Add the key ID field into the authentication tag option so that a MSK can generate multiple traffic keys.
- o 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.
- o Add the support of fragmenting EAP messages.

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

- o Editorial changes, added use cases to introduction.

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

- o Add the support of re-authentication initiated by PCP server.
- o 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.
- o Discuss the format of the PCP-Auth-Acknowledge message.
- o Remove the redundant information from the Auth OpCode, and specify new result codes transported in PCP packet headers
- o

11.5. Changes from ietf-pcp-authentication-02 to -03

- o Change the name "PCP-Auth-Request" to "PCP-Auth-Server"
- o Change the name "PCP-Auth-Response" to "PCP-Auth-Client"
- o Specify two new sequence numbers for common PCP messages in the PCP SA, and describe how to use them
- o Specify a Authentication Tag Option for PCP Common Messages
- o 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.

12. References

12.1. Normative References

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