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Port Control Protocol (PCP) Failure Scenarios
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Abstract

This document identifies and analyzes several PCP failure scenarios. A procedure to retrieve the explicit dynamic mapping(s) from the PCP Server is proposed. This procedure relies upon the use of a new PCP OpCode and Option: GET/NEXT.

Requirements Language

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

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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1. Introduction

This document discusses several failure scenarios that may occur when deploying PCP [I-D.ietf-pcp-base].

2. PCP Failure Scenarios

2.1. Change of the IP Address of The PCP Server

When a new IP address is used to reach its PCP Server, the PCP Client MUST re-create all of its explicit dynamic mappings using the newly discovered IP address.

The PCP Client must undertake the same process as per refreshing an existing explicit dynamic mapping (see [I-D.ietf-pcp-base]); the only difference is the PCP Requests are sent to a distinct IP address. No specific behavior is required from the PCP Server for handling these requests.

2.2. Application Crash

When a fatal error is encountered by an application relying on PCP to open explicit dynamic mappings on an upstream device, and upon the restart of that application, the PCP Client should issue appropriate requests to refresh the explicit dynamic mappings of that application (e.g., clear old mappings and install new ones using the new port number used by the application).

If the same port number is used but a distinct mapping nonce is generated, the request will be rejected with a NOT_AUTHORIZED error with the Lifetime of the error indicating duration of that existing mapping. This issue can be solved if the PCP Client uses GET OpCode (Section 4) to recover the mapping nonce used when instantiating the mapping.

If a distinct port number is used by the application to bound its service (i.e., a new internal port number is to be signaled in PCP), the PCP Server may honor the refresh requests if the per-subscriber quota is not exceeded. A distinct external port number would be assigned by the PCP Server due to the presence of "stale" explicit dynamic mapping(s) associated with the "old" port number.

To avoid this inconvenience induced by stale explicit dynamic mappings, the PCP Client MAY clear the "old" mappings before issuing the refresh requests; but this would require the PCP Client to store the information about the "old" port number. This can be easy to solve if the PCP Client is embedded in the application. In some

scenarios, this is not so easy because the PCP Client may handle PCP requests on behalf of several applications and no means to identify the requesting application may be supported. Means to identify the application are implementation-specific and are out of scope of this document.

A PCP Client SHOULD NOT issue a request to delete all the explicit dynamic mappings associated with an internal IP address since other applications and PCP Client(s) may use the same internal IP address to instruct their explicit dynamic mappings in the PCP Server.

2.3. PCP Client Crash

The PCP Client may encounter a fatal error leading to its restart. In such case, the internal IP address and port numbers used by requesting applications are not impacted. Therefore, the explicit dynamic mappings as maintained by the PCP Server are accurate and there is no need to refresh them.

On the PCP Client side, a new UDP port should be assigned to issue PCP requests. As a consequence, if outstanding requests have been sent to the PCP Server, the responses are likely to be lost.

If the PCP Client stores its explicit dynamic mappings in a persistent memory, there is no need to retrieve the list of active mappings from the PCP Server. If several PCP Clients are co-located on the same host, related PCP mapping tables should be uniquely distinguished (e.g., a PCP Client does not delete explicit dynamic mappings instructed by another PCP Client.)

If the PCP Client does not store the explicit dynamic mappings and new mapping nonces are assigned, the PCP Server will reject to refresh these mappings. This issue can be solved if the PCP Client uses GET OpCode (Section 4) to recover the mapping nonces used when instantiating the mappings.

If the PCP Client (or the application) is crashing, it should be allocating short PCP lifetimes until it is debugged and running properly. If it is never debugged and never running properly, it should continue to request short PCP lifetimes.

2.4. Change of the Internal IP Address

When a new IP address is assigned to a host embedding a PCP Client, the PCP Client MUST install on the PCP Server all the explicit dynamic mappings it manages, using the new assigned IP address as the internal IP address. The hinted external port number won't be assigned by the PCP Server since a "stale" mapping is already

instantiated by the PCP Server (but it is associated with a distinct internal IP address).

For a host configured with several addresses, the PCP Client MUST maintain a record about the target IP address it used when issuing its PCP requests. If no record is maintained and upon a change of the IP address or de-activation of an interface, the PCP-instructed explicit dynamic mappings are broken and inbound communications will fail to be delivered.

Depending on the configured policies, the PCP Server may honor all or part of the requests received from the PCP Client. Upon receipt of the response from the PCP Server, the PCP Client MUST update its local PCP state with the new assigned port numbers and external IP address.

> [Ed. Note: Do we need to support means to clear stale explicit dynamic mappings first? This may have an impact if the quota is exceed due to the presence of stale mappings.]

A PCP Client may be used to manage explicit dynamic mappings on behalf of a third party (i.e., the PCP Client and the third party are not co-located on the same host). If a new internal IP address is assigned to that third party (e.g., webcam), the PCP Client SHOULD be instructed to delete the old mapping(s) and create new one(s) using the new assigned internal IP address. When the PCP Client is co-located with the DHCP server (e.g., PCP Proxy [I-D.ietf-pcp-proxy], IWF in the CP router [I-D.ietf-pcp-upnp-igd-interworking]), the state can be updated using the state of the local DHCP server. Otherwise, it is safe to recommend the use of static internal IP addresses if PCP is used to configure third-party explicit dynamic mappings.

2.5. Change of the CPE WAN IP Address

The change of the IP address of the WAN interface of the CPE would have an impact on the accuracy of the explicit dynamic mappings instantiated in the PCP Server:

- For the DS-Lite case [RFC6333]: if a new IPv6 address is used by the B4 element when encapsulating IPv4 packets in IPv6 ones, the explicit dynamic mappings SHOULD be refreshed: If the PCP Client is embedded in the B4, the refresh operation is triggered by the change of the B4 IPv6 address. This would be more complicated when the PCP Client is located in a device behind the B4.

  > [Ed. Note: how an IPv4 host behind a DS-Lite CPE is aware that a new IPv6 address is used by the B4?]

- For the NAT64 case [RFC6146], any change of the assigned IPv6 prefix delegated to the CPE will be detected by the PCP Client (because this leads to the allocation of a new IPv6 address). The PCP Client has to undertake the operation described in Section 2.4.

- For the NAT444 case, similar problems are encountered because the PCP Client has no reasonable way to detect the CPE's WAN address changed.

2.6. UPnP IGD/PCP IWF

In the event an UPnP IGD/PCP IWF [I-D.ietf-pcp-upnp-igd-interworking] fails to renew a mapping, there is no mechanism to inform the UPnP Control Point about this failure.

On the reboot of the IWF, if no mapping table is maintained in a permanent storage, "stale" mappings will be maintained by the PCP Server and per-user quota will be consumed. This is even exacerbated if new mapping nonces are assigned by the IWF. This issue can be soften by synchronizing the mapping table owing to the invocation of the GET OpCode defined in Section 4.

2.7. Restart or Failure of the PCP Server

This section covers failure scenarios encountered by the PCP Server.

2.7.1. Basic Rule

In any situation the PCP Server loses all or part of its PCP state, the Epoch value MUST be reset when replying to received requests. Doing so would allow PCP Client to audit its explicit dynamic mapping table.

If the state is not lost, the PCP Server MUST NOT reset the Epoch value returned to requesting PCP Clients.

2.7.2. Clear PCP Mappings

When a command line or a configuration change is enforced to clear all or a subset of PCP explicit dynamic mappings maintained by the PCP Server, the PCP Server MUST reset its Epoch to zero value.

In order to avoid all PCP Clients to update their explicit dynamic mappings, the PCP Server SHOULD reset the Epoch to zero value only for impacted users.

2.7.3. State Redundancy is Enabled

When state redundancy is enabled, the state is not lost during failure events. Failures are therefore transparent to requesting PCP Clients. When a backup device takes over, Epoch MUST NOT be reset to zero.

2.7.4. Cold-Standby without State Redundancy

In this section we assume that a redundancy mechanisms is configured between a primary PCP-controlled device and a backup one but without activating any state synchronization for the PCP-instructed explicit dynamic mappings between the backup and the primary devices.

If the primary PCP-controlled device fails and the backup one takes over, the PCP Server MUST reset the Epoch to zero value. Doing so would allow PCP Clients to detect the loss of states in the PCP Server and proceed to state synchronization.

2.7.5. Anycast Redundancy Mode

When an anycast-based mode is deployed (i.e., the same IP address is used to reach several PCP Servers) for redundancy reasons, the change of the PCP Server which handles the requests of a given PCP Client won't be detected by that PCP Client.

Tweaking the Epoch (Section 8.5 of [I-D.ietf-pcp-base]) may help to detect the loss of state and therefore to re-create missing explicit dynamic mappings.

2.7.6. Mapping Repair Procedure

2.7.6.1. PCP Client Behaviour

[I-D.ietf-pcp-base] defines a procedure for the PCP Server to notify PCP Clients about changes related to the mappings it maintains. Indeed, the PCP Server can send unsolicited ANNOUNCE OpCode or unsolicited MAP/PEER responses. When unsolicited ANNOUNCE is received, the PCP Client proceeds to re-installing its mappings. Unsolicited PCP MAP/PEER responses received from a PCP Server are handled as any normal MAP/PEER response.

2.7.6.2. PCP Proxy Behaviour

Upon receipt of an unsolicited ANNOUNCE response from a PCP Server, the PCP Proxy proceeds to renewing the mappings and checks whether there are changes compared to a local cache if it is maintained by the PCP Proxy. If no change is detected, no unsolicited ANNOUNCE is

generated towards PCP Clients. If a change is detected, the PCP Proxy MUST generate unsolicited ANNOUNCE message(s) to appropriate PCP Clients. If the PCP Proxy does not maintain a local cache for the mappings, unsolicited ANNOUNCE messages are relayed to PCP Clients.

Unsolicited PCP MAP/PEER responses received from a PCP Server are handled as any normal MAP/PEER response. To handle unsolicited PCP MAP/PEER responses, the PCP Proxy is required to maintain a local cache of instantiated mappings in the PCP Server. When this service is supported the state SHOULD be recovered in case of failures using the procedure defined in Section 4.

Upon change of its external IP address, the PCP Proxy SHOULD renew the mappings it maintained. This can be achieved only if a full state table is maintained by the PCP Proxy.

3. PCP State Synchronization: Overview

The following sketches the state synchronization logic:

- One element (i.e., PCP Client/host/application, PCP Server, PCP Proxy, PCP IWF) of the chain is REQUIRED to use stable storage
- If the PCP Client (resp., the PCP Server) crashes and restarts it just have to synchronize with the PCP Server (resp., the PCP Client);
- If both crash then one has to use stable storage and we fall back in the previous case as soon as we know which one (the Epoch value gives this information);
- PCP Server -> PCP Client not-disruptive synchronization requires a GET/NEXT mechanism to retrieve the state from the PCP Server; without this mechanism the only way to put the PCP Server in a known state is for the PCP Client to send a delete all request, a clearly disruptive operation.
- PCP Client -> PCP Server synchronization is done by a re-create or refresh of the state. The PCP Client MAY retrieve the PCP Server state in order to prevent stale explicit dynamic mappings.

4. GET/NEXT Operation

This section defines a new PCP OpCode called GET and its associated Option NEXT.

These PCP Opcode and Option are used by the PCP Client to retrieve an explicit mapping or to walk through the explicit dynamic mapping table maintained by the PCP Server for this subscriber and retrieves a list of explicit dynamic mapping entries it instantiated.

GET can also be used by a NoC to retrieve the list of mappings for a given subscriber.

4.1. OpCode Format

The GET OpCode payload contains a Filter used for explicit dynamic mapping matching: only the explicit dynamic mappings of the subscriber which match the Filter in a request are considered so could be returned in response.

> Implementation Note: Some existing implementations use 98 (0x62) codepoint for GET OpCode, 131 for AMBIGUOUS error code, and 131 (0x83) for NEXT Option.

The layout of GET OpCode is shown in Figure 1.

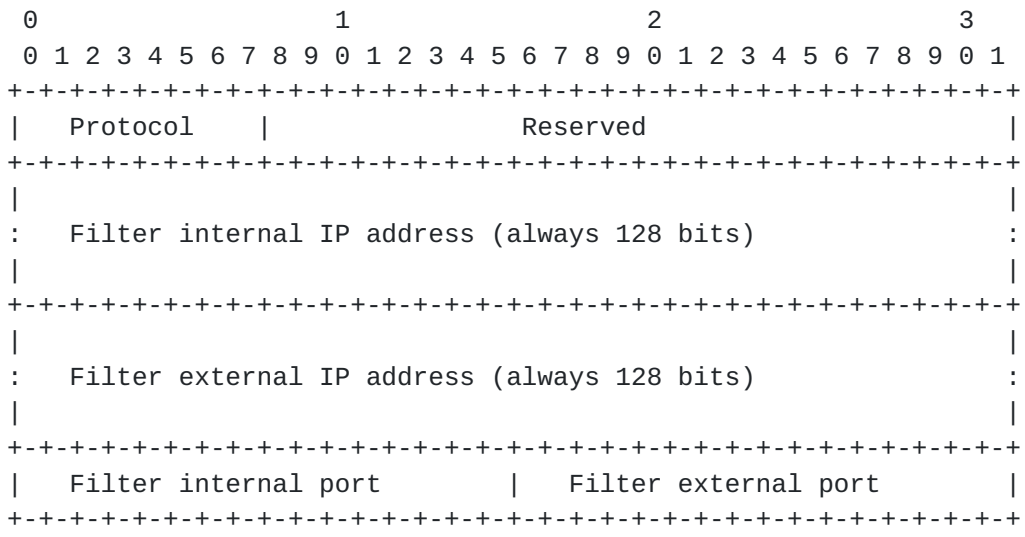


Figure 1: GET: OpCode format

For all fields, the value 0 in a request means wildcard filter/any value matches. Of course this has to be sound: no defined port with protocol set to any.

These fields are described below:

Protocol: Same than for MAP [I-D.ietf-pcp-base].

Reserved: MUST be sent as 0 and MUST be ignored when received.

Filter internal IP address: Conveys the internal IP address (including an unspecified IPv4IPv6 address). The encoding of this field follows Section 5 of [I-D.ietf-pcp-base].

Filter external IP address: Conveys the external IP address (including an unspecified IPv4IPv6 address). The encoding of this field follows Section 5 of [I-D.ietf-pcp-base].

Filter internal port: The internal port (including 0).

Filter external port: The external port (including 0).

Responses include a bit-to-bit copy of the OpCode found in the request.

4.2. OpCode-Specific Result Code

This OpCode defines two new specific Result Code

TBD: NONEXIST_MAP, e.g., no explicit dynamic mapping matching the Filter was found.

TBD: AMBIGUOUS. This code is returned when the PCP Server is not able to decide which mapping to return. Existing implementations use 131 as codepoint.

4.3. Ordering and Equality

The PCP server is required to implement an order between matching explicit dynamic mappings. The only property of this order is to be stable: it doesn't change (*) between two GET requests with the same Filter.

(*) "change" means two mappings are not gratuitously swapped: expiration, renewal or creation are authorized to change the order but they are at least expected by the PCP client.

[Ed. Note: We have two proposals for the order: lexicographical order and lifetime order. Both work, this should be left to the implementor.]

Equality is defined by:

- same protocol and;
- same internal address and;
- same external address and;
- same internal port and;
- same external port.

4.4. NEXT Option

Formal definition:

Name: NEXT

Number: at most one in requests, any in responses.

Purpose: carries a Locator in requests, matching explicit dynamic mappings greater than the Locator in responses.

Is valid for OpCodes: GET OpCode.

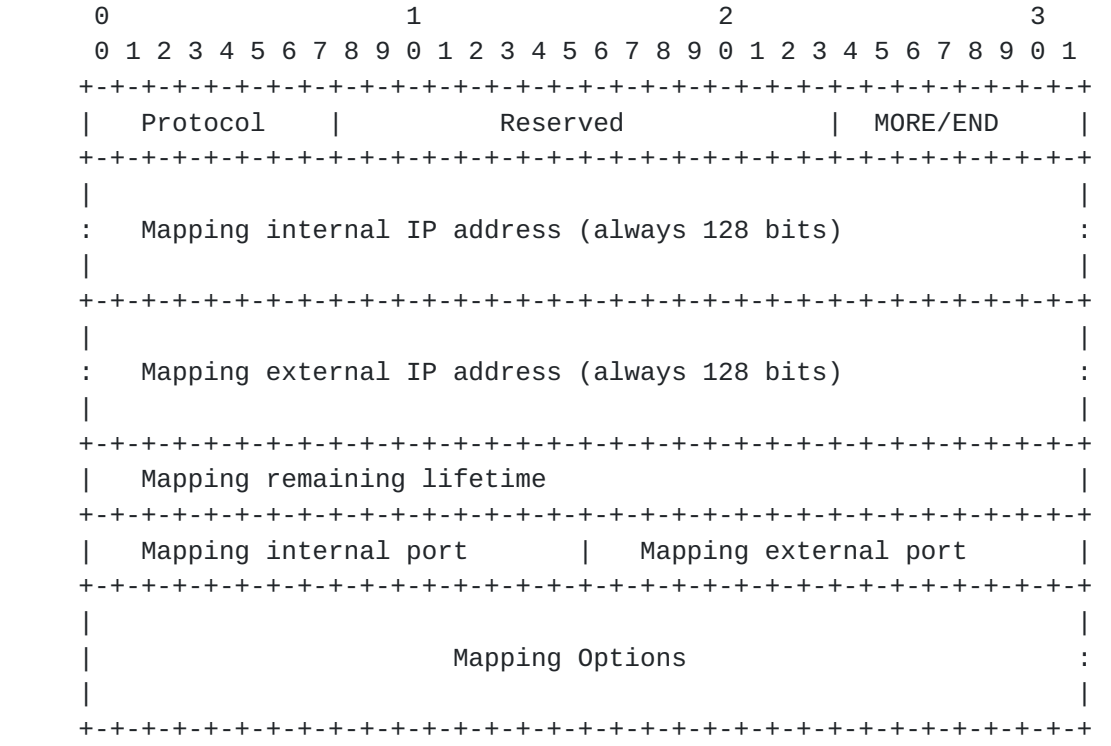
Length: variable, the minimum is 11.

May appear in: both requests and responses.

Maximum occurrences: one for requests, bounded by maximum message size for PCP responses [I-D.ietf-pcp-base].

The layout of the NEXT Option is shown in Figure 2.

Version=1



Version=2

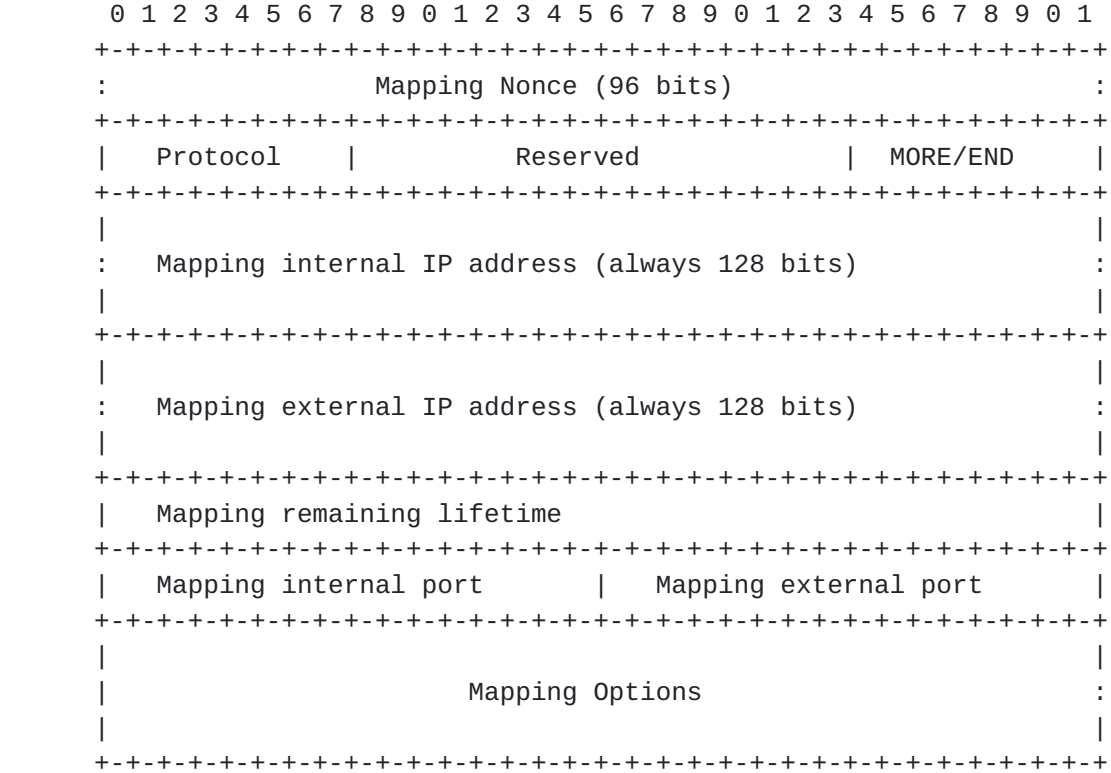


Figure 2: NEXT: Option format

In requests the NEXT Option carries a Locator: a position in the list of explicit dynamic mappings which match the Filter. The following two useful forms of Locators are considered:

- the "Undefined" form where the Protocol, Addresses, Ports fields are set to zero.

- the "Defined" form where none of the Protocol, Addresses and Ports is set to zero.

The new fields in a Locator (a.k.a., the NEXT Option in a GET request) are described below:

MORE/END: The value 0 denotes "MORE" and means the response MAY include multiple NEXT Options; a value other than 0 (1 is RECOMMENDED) denotes "END" and means the response SHALL include at most one NEXT Option.

Mapping remaining lifetime: MUST be sent as 0 and MUST be ignored when received.

Mapping Options: The Option Codes of the PCP Client wants to get in the response (e.g., THIRD_PARTY). The format is the same than for the UNPROCESSED Option (see rev 17 of[I-D.ietf-pcp-base]).

In responses the NEXT Options carry the returned explicit dynamic mappings, one per NEXT Option. The fields are described below:

Protocol: The protocol of the returned mapping.

MORE/END: The value 0 when there are explicit dynamic mapping matching the Filter and greater than this returned mapping; a value other than 0 (1 is RECOMMENDED) when the return mapping is the greatest explicit dynamic mapping matching the Filter.

Mapping internal IP address: the internal address of the returned mapping. The encoding of this field follows Section 5 of [I-D.ietf-pcp-base].

Mapping external IP address: the external address of the returned mapping. The encoding of this field follows Section 5 of [I-D.ietf-pcp-base].

Mapping remaining lifetime: The remaining lifetime in seconds of the returned mapping.

Mapping internal port: the internal port of the returned mapping.

Mapping external port: the external port of the returned mapping.

Mapping Options: An embedded list of option values. Each corresponding Option Code MUST be present in the request NEXT Option, each option MUST be related to the returned mapping or not related to any mapping.

4.5. GET/NEXT PCP Client Theory of Operation

GET requests without a NEXT Option have low usage but with a full wildcard Filter they ask the PCP Server to know if it has at least one explicit dynamic mapping for this subscriber.

GET requests with an END NEXT Option are "pure" GET: they asks for the status and/or the remaining lifetime or options of a specific explicit dynamic mapping. It is recommended to use an Undefined Locator and to use the Filter to identify the mapping.

GET requests with a MORE NEXT Option are for the whole explicit dynamic mapping table retrieval from the PCP Server. The initial request contains an Undefined Locator, other requests a Defined Locator filled by a copy of the last returned mapping with the Lifetime and Option fields reseted to the original values. An END NEXT Option marks the end of the retrieval.

4.6. GET/NEXT PCP Server Theory of Operation

The PCP Server behavior is described below:

- on the reception of a valid GET request the ordered list of explicit dynamic mapping of the subscriber matching the given Filter is (conceptually) built.

- if the list is empty a NONEXIST_MAP error response is returned. It includes no NEXT Option.

- the list is scanned to find the Locator using the Equality defined in Section 4.3. If it is found the mappings less than the Locator are removed from the list, so the result is a list which begins by the mapping equals to the Locator followed by greater mappings.

- if the NEXT Option in the request is an END one, the first mapping of the list is returned in an only NEXT option, marked END if the

list contains only this mapping, marked MORE otherwise.

- o if the NEXT option in the request is a MORE one, as many as can fit mappings are returned in order in the response, marked as MORE but if the whole list can be returned the last is marked END.

"Returned" means to include required options when they are defined for a mapping: if the mapping M has 3 REMOTE_PEER_FILTERs and the REMOTE_PEER_FILTER code was in the request NEXT, the NEXT carrying M will get the 3 REMOTE_PEER_FILTER options embedded.

5. Flow Examples

As an illustration example, let's consider the following explicit dynamic mapping table is maintained by the PCP Server:

Pro	Internal IP Address	Internal Port	External IP Address	External Port	Remaining Lifetime
UDP	198.51.100.1	25655	192.0.2.1	15659	1659
TCP	198.51.100.2	12354	192.0.2.1	32654	3600
TCP	198.51.100.2	8596	192.0.2.1	25659	6000
UDP	198.51.100.1	19856	192.0.2.1	42654	7200
TCP	198.51.100.1	15775	192.0.2.1	32652	9000

Table 1: Excerpt of a mapping table

As shown in Table 1, the PCP Server sorts the explicit dynamic mapping table using the internal IP address and the remaining lifetime.

Figure 3 illustrates the exchange that occurs when a PCP Client tries to retrieve the information related to a non-existing explicit dynamic mapping.

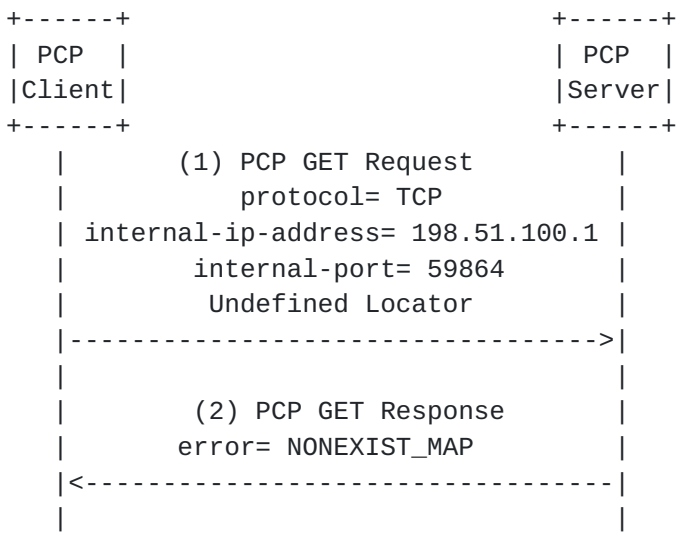


Figure 3: Example of a failed GET operation

Figure 4 shows an example of a PCP Client which retrieves successfully an existing mapping from the PCP Server.

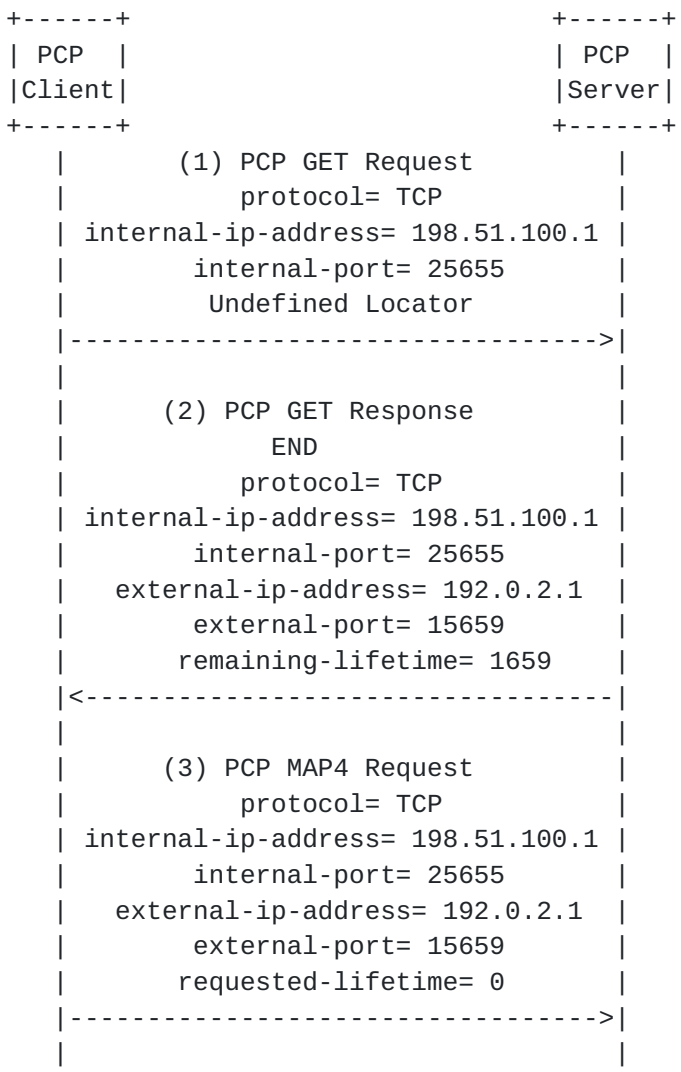


Figure 4: Example of a successful GET operation

In reference to Figure 5, the PCP Server returns the explicit dynamic mappings having the internal address equal to 192.0.2.1 ordered by increasing remaining lifetime.

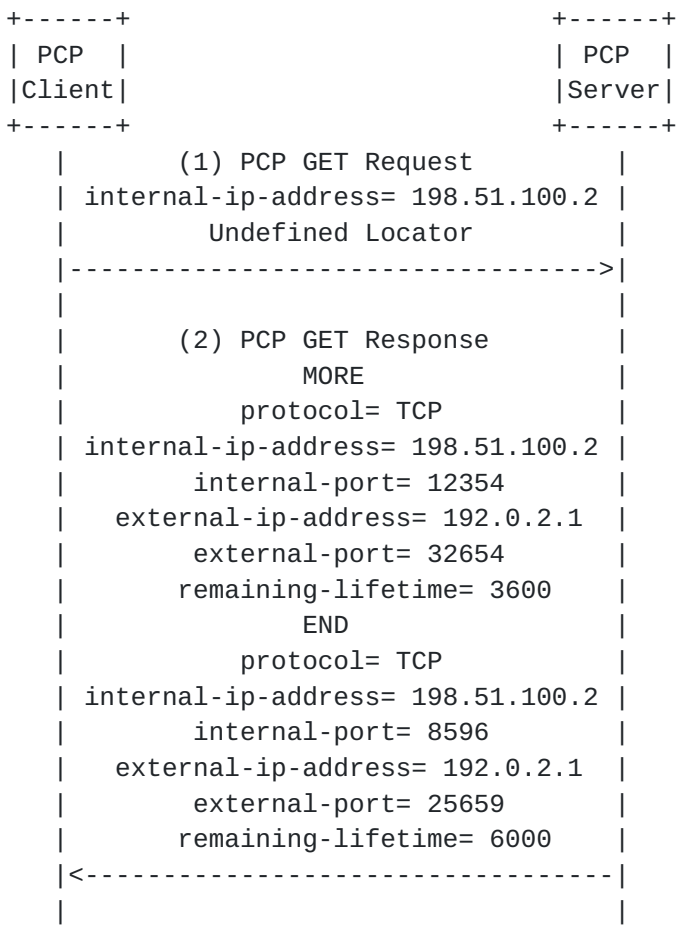


Figure 5: Flow example of GET/NEXT

In reference to Figure 6, the PCP Server returns the explicit dynamic mappings having the internal address equal to 192.0.2.2 ordered by increasing remaining lifetime. In this example, the same internal port is used for TCP and UDP.

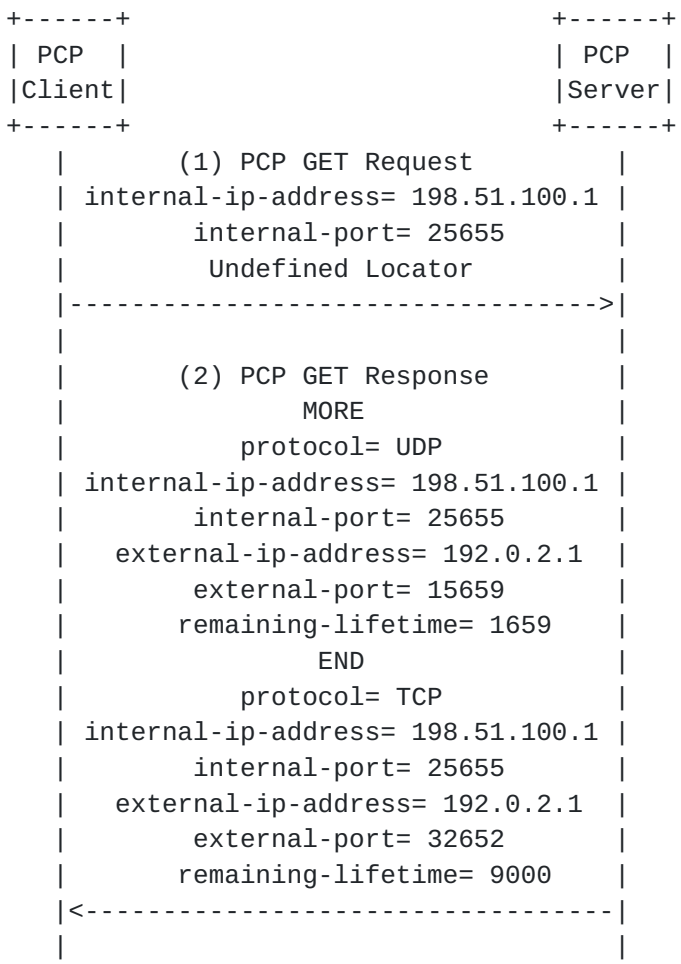


Figure 6: Flow example of GET/NEXT: same internal port number

6. Security Considerations

TBD.

[Ed. Two comments:

* About the stable storage if this scenario is possible:

  1. subscriber A gets a mapping

  2. the PCP Server crashes and reboots

  3. subscriber B gets the same mapping

  then the PCP Server MUST keep its state in a stable storage, i.e., it MUST NOT forget mappings.

* About GET/NEXT, typically if a PCP Client is allowed to delete a mapping it SHOULD be allowed to retrieve it; and if it is not allowed to delete a mapping it MUST NOT be allowed to retrieve it.]

7. IANA Considerations

The following OpCode is requested:

o GET

The folloiwng Option code is requested:

o NEXT

The following error codes are requested:

o NONEXIST_MAP

o AMBIGUOUS

8. References

8.1. Normative References

[I-D.ietf-pcp-base]
Wing, D., Cheshire, S., Boucadair, M., Penno, R., and P. Selkirk, "Port Control Protocol (PCP)", draft-ietf-pcp-base-26 (work in progress), June 2012.

[I-D.ietf-pcp-proxy]
Boucadair, M., Dupont, F., Penno, R., and D. Wing, "Port Control Protocol (PCP) Proxy Function", draft-ietf-pcp-proxy-01 (work in progress), August 2012.

[I-D.ietf-pcp-upnp-igd-interworking]
Boucadair, M., Dupont, F., Penno, R., and D. Wing, "Universal Plug and Play (UPnP) Internet Gateway Device (IGD)-Port Control Protocol (PCP) Interworking Function", draft-ietf-pcp-upnp-igd-interworking-02 (work in progress), August 2012.

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

8.2. Informative References

[RFC6146] Bagnulo, M., Matthews, P., and I. van Beijnum, "Stateful NAT64: Network Address and Protocol Translation from IPv6 Clients to IPv4 Servers", RFC 6146, April 2011.

[RFC6333] Durand, A., Droms, R., Woodyatt, J., and Y. Lee, "Dual-Stack Lite Broadband Deployments Following IPv4 Exhaustion", RFC 6333, August 2011.

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