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Constrained Application Protocol (CoAP) Block-Wise Transfer Options for
Faster Transmission
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Abstract

This document specifies alternative Constrained Application Protocol (CoAP) Block-Wise transfer options: Q-Block1 and Q-Block2 Options.

These options are similar to the CoAP Block1 and Block2 Options, not a replacement for them, but do enable faster transmission rates for large amounts of data with less packet interchanges as well as supporting faster recovery should any of the blocks get lost in transmission.

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[1.](#) Introduction

The Constrained Application Protocol (CoAP) [[RFC7252](#)], although inspired by HTTP, was designed to use UDP instead of TCP. The message layer of CoAP over UDP includes support for reliable delivery, simple congestion control, and flow control. [[RFC7959](#)] introduced the CoAP Block1 and Block2 Options to handle data records that cannot fit in a single IP packet, so not having to rely on IP fragmentation and was further updated by [[RFC8323](#)] for use over TCP, TLS, and WebSockets.

The CoAP Block1 and Block2 Options work well in environments where there are no or minimal packet losses. These options operate synchronously where each individual block has to be requested and can only ask for (or send) the next block when the request for the previous block has completed. Packet, and hence block transmission rate, is controlled by Round Trip Times (RTTs).

There is a requirement for these blocks of data to be transmitted at higher rates under network conditions where there may be asymmetrical transient packet loss (i.e., responses may get dropped). An example is when a network is subject to a Distributed Denial of Service (DDoS) attack and there is a need for DDoS mitigation agents relying upon CoAP to communicate with each other (e.g., [[I-D.ietf-dots-telemetry](#)]). As a reminder, [[RFC7959](#)] recommends the use of Confirmable (CON) responses to handle potential packet loss. However, such a recommendation does not work with a flooded pipe DDoS situation.

[1.1.](#) Alternative CoAP Block-Wise Transfer Options

This document introduces the CoAP Q-Block1 and Q-Block2 Options. These options are similar in operation to the CoAP Block1 and Block2 Options, respectively. They are not a replacement for them, but have the following benefits:

- o They can operate in environments where packet loss is highly asymmetrical.
- o They enable faster transmissions of sets of blocks of data with less packet interchanges.
- o They support faster recovery should any of the blocks get lost in transmission.
- o They support sending an entire body using Non-confirmable (NON) without requiring a response from the peer.

There are the following disadvantages over using CoAP Block1 and Block2 Options:

- o Loss of lock-stepping so payloads are not always received in the correct (block ascending) order.
- o Additional congestion control measures need to be put in place for NON ([Section 6.2](#)).
- o To reduce the transmission times for CON transmission of large bodies, NSTART needs to be increased from 1, but this affects congestion control where other parameters need to be tuned ([Section 4.7 of \[RFC7252\]](#)). Such tuning is out of scope of this document.
- o The Q-Block Options do not support stateless operation/random access.
- o Proxying of Q-Block is limited to caching full representations.
- o There is no multicast support.

Using NON messages, the faster transmissions occur as all the blocks can be transmitted serially (as are IP fragmented packets) without having to wait for a response or next request from the remote CoAP peer. Recovery of missing blocks is faster in that multiple missing blocks can be requested in a single CoAP packet. Even if there is asymmetrical packet loss, a body can still be sent and received by the peer whether the body comprises of a single or multiple payloads assuming no recovery is required.

A CoAP endpoint can acknowledge all or a subset of the blocks. Concretely, the receiving CoAP endpoint informs the CoAP sender endpoint either successful receipt or reports on all blocks in the body that have not yet been received. The CoAP sender endpoint will then retransmit only the blocks that have been lost in transmission.

Note that similar performance benefits can be applied to Confirmable messages if the value of NSTART is increased from 1 ([Section 4.7 of \[RFC7252\]](#)). However, the use of Confirmable messages will not work if there is asymmetrical packet loss. Some examples with Confirmable messages are provided in [Appendix A](#).

There is little, if any, benefit of using these options with CoAP running over a reliable connection [[RFC8323](#)]. In this case, there is no differentiation between Confirmable and NON as they are not used. Some examples using a reliable transport are provided in [Appendix B](#).

Q-Block1 and Q-Block2 Options can be used instead of Block1 and Block2 Options when the different transmission properties are required. If the new option is not supported by a peer, then transmissions can fall back to using Block1 and Block2 Options.

The deviations from Block1 and Block2 Options are specified in [Section 3](#). Pointers to appropriate [[RFC7959](#)] sections are provided.

The specification refers to the base CoAP methods defined in [Section 5.8 of \[RFC7252\]](#) and the new CoAP methods, FETCH, PATCH, and iPATCH introduced in [[RFC8132](#)].

Q-Block1 and Q-Block2 Options are designed to work in particular with Non-confirmable requests and responses.

The No-Response Option was considered but was abandoned as it does not apply to Q-Block2 responses. A unified solution is defined in the document.

[1.2.](#) CoAP Response Code (4.08) Usage

This document adds a media type for the 4.08 (Request Entity Incomplete) response defining an additional message format for reporting on payloads using the Q-Block1 Option that are not received by the server.

See [Section 4](#) for more details.

[1.3.](#) Applicability Scope

The block-wise transfer specified in [[RFC7959](#)] covers the general case, but falls short in situations where packet loss is highly asymmetrical. The mechanism specified in this document provides roughly similar features to the Block1/Block2 Options. It provides additional properties that are tailored towards the intended use case of Non-Confirmable transmission. Concretely, this mechanism primarily targets applications such as DDoS Open Threat Signaling

(DOTS) that can't use Confirmable (CON) responses to handle potential packet loss and that support application-specific mechanisms to assess whether the remote peer is able to handle the messages sent by a CoAP endpoint (e.g., DOTS heartbeats in [Section 4.7 of \[RFC8782\]](#)).

The mechanism includes guards to prevent a CoAP agent from overloading the network by adopting an aggressive sending rate. These guards MUST be followed in addition to the existing CoAP congestion control as specified in [Section 4.7 of \[RFC7252\]](#). See [Section 6](#) for more details.

This mechanism is not intended for general CoAP usage, and any use outside the intended use case should be carefully weighed against the loss of interoperability with generic CoAP applications. It is hoped that the experience gained with this mechanism can feed future extensions of the block-wise mechanism that will both be generally applicable and serve this particular use case.

It is not recommended that these options are used in a NoSec security mode ([Section 9 of \[RFC7252\]](#)) as the source endpoint needs to be trusted. Using OSCORE [\[RFC8613\]](#) does provide a security context and, hence, a trust of the source endpoint. However, using a NoSec security mode may still be inadequate for reasons discussed in [Section 11](#).

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [BCP 14 \[RFC2119\]](#)[\[RFC8174\]](#) when, and only when, they appear in all capitals, as shown here.

Readers should be familiar with the terms and concepts defined in [\[RFC7252\]](#).

The terms "payload" and "body" are defined in [\[RFC7959\]](#). The term "payload" is thus used for the content of a single CoAP message (i.e., a single block being transferred), while the term "body" is used for the entire resource representation that is being transferred in a block-wise fashion.

3. The Q-Block1 and Q-Block2 Options

3.1. Properties of Q-Block1 and Q-Block2 Options

The properties of Q-Block1 and Q-Block2 Options are shown in Table 1. The formatting of this table follows the one used in Table 4 of [RFC7252] (Section 5.10). The C, U, N, and R columns indicate the properties Critical, UnSafe, NoCacheKey, and Repeatable defined in Section 5.4 of [RFC7252]. Only Critical and UnSafe columns are marked for the Q-Block1 Option. Critical, UnSafe, and Repeatable columns are marked for the Q-Block2 Option. As these options are UnSafe, NoCacheKey has no meaning and so is marked with a dash.

Number	C	U	N	R	Name	Format	Length	Default
TBA1	x	x	-		Q-Block1	uint	0-3	(none)
TBA2	x	x	-	x	Q-Block2	uint	0-3	(none)

Table 1: CoAP Q-Block1 and Q-Block2 Option Properties

The Q-Block1 and Q-Block2 Options can be present in both the request and response messages. The Q-Block1 Option pertains to the request payload and the Q-Block2 Option pertains to the response payload. The Content-Format Option applies to the body, not to the payload (i.e., it must be the same for all payloads of the same body).

Q-Block1 Option is useful with the payload-bearing POST, PUT, FETCH, PATCH, and iPATCH requests and their responses.

Q-Block2 Option is useful with GET, POST, PUT, FETCH, PATCH, and iPATCH requests and their payload-bearing responses (2.01, 2.02, 2.03, 2.04, and 2.05) (Section 5.5 of [RFC7252]).

A CoAP endpoint (or proxy) MUST support either both or neither of the Q-Block1 and Q-Block2 Options.

If Q-Block1 Option is present in a request or Q-Block2 Option in a response (i.e., in that message to the payload of which it pertains), it indicates a block-wise transfer and describes how this specific block-wise payload forms part of the entire body being transferred. If it is present in the opposite direction, it provides additional control on how that payload will be formed or was processed.

To indicate support for Q-Block2 responses, the CoAP client MUST include the Q-Block2 Option in a GET or similar request, the Q-Block2 Option in a PUT or similar request, or the Q-Block1 Option in a PUT or similar so that the server knows that the client supports this Q-Block2 functionality should it need to send back a body that spans

multiple payloads. Otherwise, the server would use the Block2 Option (if supported) to send back a message body that is too large to fit into a single IP packet [[RFC7959](#)].

Alternatively, with CoAP over reliable transports, Capabilities and Settings Messages (CSMs) can be used to indicate support of Q-Block Options by means of the Q-Block-Wise-Transfer Capability Option (Table 2). The behavior of CoAP peers is similar to the one specified in [Section 5.3.2 of \[RFC8323\]](#), except that it indicates support of Q-Block Options.

#	C	R	Applies to	Name	Format	Length	Base Value
TBA4			CSM	Q-Block-Wise-Transfer	empty	0	(none)

C=Critical, R=Repeatable

Table 2: The Q-Block-Wise-Transfer Capability Option

Implementation of the Q-Block1 and Q-Block2 Options is intended to be optional. However, when it is present in a CoAP message, it MUST be processed (or the message rejected). Therefore, Q-Block1 and Q-Block2 Options are identified as Critical options.

With CoAP over UDP, the way a request message is rejected for critical options depends on the message type. A Confirmable message with an unrecognized critical option is rejected with a 4.02 (Bad Option) response ([Section 5.4.1 of \[RFC7252\]](#)). A Non-confirmable message with an unrecognized critical option is either rejected with a Reset message or just silently ignored (Sections [5.4.1](#) and [4.3](#) of [[RFC7252](#)]). To reliably get a rejection message, it is therefore REQUIRED that clients use a Confirmable message for determining support for Q-Block1 and Q-Block2 Options.

The Q-Block1 and Q-Block2 Options are unsafe to forward. That is, a CoAP proxy that does not understand the Q-Block1 (or Q-Block2) Option MUST reject the request or response that uses either option.

The Q-Block2 Option is repeatable when requesting retransmission of missing blocks, but not otherwise. Except that case, any request carrying multiple Q-Block1 (or Q-Block2) Options MUST be handled following the procedure specified in [Section 5.4.5 of \[RFC7252\]](#).

The Q-Block1 and Q-Block2 Options, like the Block1 and Block2 Options, are both a class E and a class U in terms of OSCORE processing (Table 3). The Q-Block1 (or Q-Block2) Option MAY be an Inner or Outer option ([Section 4.1 of \[RFC8613\]](#)). The Inner and Outer values are therefore independent of each other. The Inner option is encrypted and integrity protected between clients and servers, and provides message body identification in case of end-to-end fragmentation of requests. The Outer option is visible to proxies and labels message bodies in case of hop-by-hop fragmentation of requests.

+-----+-----+-----+-----+		+-----+-----+	
Number	Name	E	U
+=====+		+=====+	
TBA1	Q-Block1	x	x
TBA2	Q-Block2	x	x
+-----+-----+-----+-----+		+-----+-----+	

Table 3: OSCORE Protection of Q-Block1 and Q-Block2 Options

Note that if Q-Block1 or Q-Block2 Options are included in a packet as Inner options, Block1 or Block2 Options MUST NOT be included as Inner options. Similarly there MUST NOT be a mix of Q-Block and Block for the Outer options. Q-Block and Block Options can be mixed across Inner and Outer options as these are handled independently of each other.

[3.2.](#) Structure of Q-Block1 and Q-Block2 Options

The structure of Q-Block1 and Q-Block2 Options follows the structure defined in [Section 2.2 of \[RFC7959\]](#).

There is no default value for the Q-Block1 and Q-Block2 Options. Absence of one of these options is equivalent to an option value of 0 with respect to the value of block number (NUM) and more bit (M) that could be given in the option, i.e., it indicates that the current block is the first and only block of the transfer (block number is set to 0, M is unset). However, in contrast to the explicit value 0, which would indicate a size of the block (SZX) of 0, and thus a size value of 16 bytes, there is no specific explicit size implied by the absence of the option -- the size is left unspecified. (As for any uint, the explicit value 0 is efficiently indicated by a zero-length option; this, therefore, is different in semantics from the absence of the option).

3.3. Using the Q-Block1 Option

The Q-Block1 Option is used when the client wants to send a large amount of data to the server using the POST, PUT, FETCH, PATCH, or iPATCH methods where the data and headers do not fit into a single packet.

When Q-Block1 Option is used, the client MUST include a Request-Tag Option [[I-D.ietf-core-echo-request-tag](#)]. The Request-Tag value MUST be the same for all of the requests for the body of data that is being transferred. It is also used to identify a particular payload of a body that needs to be retransmitted. The Request-Tag is opaque, the server still treats it as opaque but the client SHOULD ensure that it is unique for every different body of transmitted data.

Implementation Note: It is suggested that the client treats the Request-Tag as an unsigned integer of 8 bytes in length. An implementation may want to consider limiting this to 4 bytes to reduce packet overhead size. The initial Request-Tag value should be randomly generated and then subsequently incremented by the client whenever a new body of data is being transmitted between peers.

[Section 3.6](#) discusses the use of Size1 Option.

For Confirmable transmission, the server continues to acknowledge each packet, but a response is not required (whether separate or piggybacked) until successful receipt of the body by the server. For Non-confirmable transmission, no response is required until the successful receipt of the body by the server or some of the payloads have not arrived after a timeout and a retransmit missing payloads response is needed. For reliable transports (e.g., [[RFC8323](#)]), a response is not required until successful receipt of the body by the server.

Each individual payload of the body is treated as a new request ([Section 5](#)).

The client MUST send the payloads with the block numbers increasing, starting from zero, until the body is complete (subject to any congestion control ([Section 6](#))). Any missing payloads requested by the server must in addition be separately transmitted with increasing block numbers.

The following Response Codes are used:

2.01 (Created)

This Response Code indicates successful receipt of the entire body and the resource was created. The token used SHOULD be from the last received payload. The client should then release all of the tokens used for this body.

2.02 (Deleted)

This Response Code indicates successful receipt of the entire body and the resource was deleted when using POST ([Section 5.8.2 \[RFC7252\]](#)). The token used SHOULD be from the last received payload. The client should then release all of the tokens used for this body.

2.04 (Changed)

This Response Code indicates successful receipt of the entire body and the resource was updated. The token used SHOULD be from the last received payload. The client should then release all of the tokens used for this body.

2.05 (Content)

This Response Code indicates successful receipt of the entire FETCH request body ([Section 2 of \[RFC8132\]](#)) and the appropriate representation of the resource is being returned. The token used in the response SHOULD be from the last received payload. If the FETCH request includes the Observe Option, then the server MUST use the same token for returning any Observe triggered responses so that the client can match them up. The client should then release all of the tokens used for this body unless a resource is being observed.

2.31 (Continue)

This Response Code can be used to indicate that all of the blocks up to and including the Q-Block1 Option block NUM (all having the M bit set) in the response have been successfully received. The token used SHOULD be from the last received payload.

A response using this Response Code SHOULD NOT be generated for every received Q-Block1 Option request. It SHOULD only be generated when all the payload requests are Non-confirmable and MAX_PAYLOADS ([Section 6.2](#)) payloads have been received by the server.

It SHOULD NOT be generated for CON.

4.00 (Bad Request)

This Response Code MUST be returned if the request does not include both a Request-Tag Option and a Size1 Option but does include a Q-Block1 option.

4.02 (Bad Option)

Either this Response Code (in case of Confirmable request) or a reset message (in case of Non-confirmable request) MUST be returned if the server does not support the Q-Block Options.

4.08 (Request Entity Incomplete)

This Response Code returned without Content-Type "application/missing-blocks+cbor-seq" ([Section 10.3](#)) is handled as in [Section 2.9.2 \[RFC7959\]](#).

This Response Code returned with Content-Type "application/missing-blocks+cbor-seq" indicates that some of the payloads are missing and need to be resent. The client then retransmits the missing payloads using the same Request-Tag, Size1 and Q-Block1 to specify the block NUM, SZX, and M bit as appropriate.

The Request-Tag value to use is determined by taking the token in the 4.08 (Request Entity Incomplete) response, locating the matching client request, and then using its Request-Tag.

The token used in the response SHOULD be from the last received payload. See [Section 4](#) for further information.

4.13 (Request Entity Too Large)

This Response Code can be returned under similar conditions to those discussed in [Section 2.9.3 of \[RFC7959\]](#).

This Response Code can be returned if there is insufficient space to create a response PDU with a block size of 16 bytes (SZX = 0) to send back all the response options as appropriate. In this case, the Size1 Option is not included in the response.

If the server has not received all the payloads of a body, but one or more NON payloads have been received, it SHOULD wait for up to NON_RECEIVE_TIMEOUT ([Section 6.2](#)) before sending a 4.08 (Request Entity Incomplete) response. Further considerations related to the transmission timings of 4.08 (Request Entity Incomplete) and 2.31 (Continue) Response Codes are discussed in [Section 6.2](#).

If a server receives payloads with different Request-Tags for the same resource, it should continue to process all the bodies as it has

no way of determining which is the latest version, or which body, if any, the client is terminating the transmission for.

If the client elects to stop the transmission of a complete body, it SHOULD "forget" all tracked tokens associated with the body's Request-Tag so that a reset message is generated for the invalid token in the 4.08 (Request Entity Incomplete) response. The server on receipt of the reset message SHOULD delete the partial body.

If the server receives a duplicate block with the same Request-Tag, it SHOULD ignore the payload of the packet, but MUST still respond as if the block was received for the first time.

A server SHOULD only maintain a partial body (missing payloads) for up to NON_PARTIAL_TIMEOUT ([Section 6.2](#)).

3.4. Using the Q-Block2 Option

In a request for any block number, the M bit unset indicates the request is just for that block. If the M bit is set, this has different meanings based on the NUM value:

NUM is zero: This is a request for the entire body.

'NUM modulo MAX_PAYLOADS' is zero, while NUM is not zero: This is used to confirm that the current set of MAX_PAYLOADS payloads (the latest one having block number NUM-1) has been successfully received and that, upon receipt of this request, the server can continue to send the next set of payloads (the first one having block number NUM). This is the 'Continue' Q-Block-2 and conceptually has the same usage (i.e., continue sending the next set of data) as the use of 2.31 (Continue) for Q-Block1.

Any other value of NUM: This is a request for that block and for all of the remaining blocks in the current MAX_PAYLOADS set.

If the request includes multiple Q-Block2 Options and these options overlap (e.g., combination of M being set (this and later blocks) and being unset (this individual block)) resulting in an individual block being requested multiple times, the server MUST only send back one instance of that block. This behavior is meant to prevent amplification attacks.

The payloads sent back from the server as a response MUST all have the same ETag ([Section 5.10.6 of \[RFC7252\]](#)) for the same body. The server MUST NOT use the same ETag value for different representations of a resource.

The ETag is opaque, the client still treats it as opaque but the server SHOULD ensure that it is unique for every different body of transmitted data.

Implementation Note: It is suggested that the server treats the ETag as an unsigned integer of 8 bytes in length. An implementation may want to consider limiting this to 4 bytes to reduce packet overhead size. The initial ETag value should be randomly generated and then subsequently incremented by the server whenever a new body of data is being transmitted between peers.

[Section 3.6](#) discusses the use of Size2 Option.

The client may elect to request any detected missing blocks or just ignore the partial body. This decision is implementation specific.

The client SHOULD wait for up to NON_RECEIVE_TIMEOUT ([Section 6.2](#)) after the last received payload for NON payloads before issuing a GET, POST, PUT, FETCH, PATCH, or iPATCH request that contains one or more Q-Block2 Options that define the missing blocks with the M bit unset. It is permissible to set the M bit to request this and missing blocks from this MAX_PAYLOADS set. Further considerations related to the transmission timing for missing requests are discussed in [Section 6.2](#).

The requested missing block numbers MUST have an increasing block number in each additional Q-Block2 Option with no duplicates. The server SHOULD respond with a 4.00 (Bad Request) to requests not adhering to this behavior.

For Confirmable responses, the client continues to acknowledge each packet. The server acknowledges the initial request using an ACK with the payload, and then sends the subsequent payloads as CON responses. The server will detect failure to send a packet, but the client can issue, after a MAX_TRANSMIT_SPAN delay, a separate GET, POST, PUT, FETCH, PATCH, or iPATCH for any missing blocks as needed.

If the client receives a duplicate block with the same ETag, it SHOULD silently ignore the packet.

A client SHOULD only maintain a partial body (missing payloads) for up to NON_PARTIAL_TIMEOUT ([Section 6.2](#)) or as defined by the Max-Age Option (or its default of 60 seconds ([Section 5.6.1 of \[RFC7252\]](#))), whichever is the less.

The ETag Option should not be used in the request for missing blocks as the server could respond with a 2.03 (Valid Response) with no

payload. It can be used in the request if the client wants to check the freshness of the locally cached body response.

It is RECOMMENDED that the server maintains a cached copy of the body when using the Q-Block2 Option to facilitate retransmission of any missing payloads.

If the server detects part way through a body transfer that the resource data has changed and the server is not maintaining a cached copy of the old data, then the transmission is terminated. Any subsequent missing block requests MUST be responded to using the latest ETag and Size2 Option values with the updated data.

If the server responds during a body update with a different ETag Option value (as the resource representation has changed), then the client should treat the partial body with the old ETag as no longer being fresh.

If the server transmits a new body of data (e.g., a triggered Observe) with a new ETag to the same client as an additional response, the client should remove any partially received body held for a previous ETag for that resource as it is unlikely the missing blocks can be retrieved.

If there is insufficient space to create a response PDU with a block size of 16 bytes (SZX = 0) to send back all the response options as appropriate, a 4.13 (Request Entity Too Large) is returned without the Size1 Option.

3.5. Using Observe Option

For a request that uses Q-Block1, the Observe value [[RFC7641](#)] MUST be the same for all the payloads of the same body. This includes any missing payloads that are retransmitted.

For a response that uses Q-Block2, the Observe value MUST be the same for all the payloads of the same body. This includes payloads transmitted following receipt of the 'Continue' Q-Block2 Option ([Section 3.4](#)) by the server. If a missing payload is requested, then both the request and response MUST NOT include the Observe Option.

3.6. Using Size1 and Size2 Options

[Section 4 of \[RFC7959\]](#) defines two CoAP options: Size1 for indicating the size of the representation transferred in requests and Size2 for indicating the size of the representation transferred in responses.

The Size1 or Size2 option values MUST exactly represent the size of the data on the body so that any missing data can easily be determined.

The Size1 Option MUST be used with the Q-Block1 Option when used in a request and MUST be present in all payloads of the request preserving the same value. The Size2 Option MUST be used with the Q-Block2 Option when used in a response and MUST be present in all payloads of the response preserving the same value.

3.7. Using Q-Block1 and Q-Block2 Options Together

The behavior is similar to the one defined in [Section 3.3 of \[RFC7959\]](#) with Q-Block1 substituted for Block1 and Q-Block2 for Block2.

3.8. Using Q-Block2 Option With Multicast

Servers MUST ignore multicast requests that contain the Q-Block2 Option. As a reminder, Block2 Option can be used as stated in [Section 2.8 of \[RFC7959\]](#).

4. The Use of 4.08 (Request Entity Incomplete) Response Code

4.08 (Request Entity Incomplete) Response Code has a new Content-Type "application/missing-blocks+cbor-seq" used to indicate that the server has not received all of the blocks of the request body that it needs to proceed.

Likely causes are the client has not sent all blocks, some blocks were dropped during transmission, or the client has sent them sufficiently long ago that the server has already discarded them.

The data payload of the 4.08 (Request Entity Incomplete) response is encoded as a CBOR Sequence [\[RFC8742\]](#). It comprises of one or more CBOR encoded [\[RFC8949\]](#) missing block numbers. The missing block numbers MUST be unique in each 4.08 (Request Entity Incomplete) response when created by the server; the client SHOULD drop any duplicates in the same 4.08 (Request Entity Incomplete) response.

The Content-Format Option ([Section 5.10.3 of \[RFC7252\]](#)) MUST be used in the 4.08 (Request Entity Incomplete) response. It MUST be set to "application/missing-blocks+cbor-seq" ([Section 10.3](#)).

The Concise Data Definition Language [\[RFC8610\]](#) (and see [Section 4.1 \[RFC8742\]](#)) for the data describing these missing blocks is as follows:


```
; A notional array, the elements of which are to be used
; in a CBOR Sequence:
payload = [+ missing-block-number]
; A unique block number not received:
missing-block-number = uint
```

Figure 1: Structure of the Missing Blocks Payload

The token to use for the response SHOULD be the token that was used in the last block number received so far with the same Request-Tag value. Note that the use of any received token with the same Request-Tag would work, but providing the one used in the last received payload will aid any troubleshooting. The client will use the token to determine what was the previously sent request to obtain the Request-Tag value to be used.

If the size of the 4.08 (Request Entity Incomplete) response packet is larger than that defined by [Section 4.6 \[RFC7252\]](#), then the number of missing blocks MUST be limited so that the response can fit into a single packet. If this is the case, then the server can send subsequent 4.08 (Request Entity Incomplete) responses containing the missing other blocks on receipt of a new request providing a missing payload with the same Request-Tag.

The missing blocks MUST be reported in ascending order without any duplicates. The client SHOULD silently drop 4.08 (Request Entity Incomplete) responses not adhering with this behavior.

Implementation Note: Consider limiting the number of missing payloads to MAX_PAYLOADS to minimize congestion control being needed. The CBOR sequence does not include any array wrapper.

The 4.08 (Request Entity Incomplete) with Content-Type "application/missing-blocks+cbor-seq" SHOULD NOT be used when using Confirmable requests or a reliable connection [\[RFC8323\]](#) as the client will be able to determine that there is a transmission failure of a particular payload and hence that the server is missing that payload.

5. The Use of Tokens

Each new request generally uses a new Token (and sometimes must, see Section 4 of [\[I-D.ietf-core-echo-request-tag\]](#)). Additional responses to a request all use the token of the request they respond to.

Implementation Note: To minimize on the number of tokens that have to be tracked by clients, it is suggested that the bottom 32 bits is kept the same for the same body and the upper 32 bits contains the current body's request number (incrementing every request,

including every re-transmit). This allows the client to be alleviated from keeping all the per-request-state, e.g., in [Section 3 of \[RFC8974\]](#).

6. Congestion Control for Unreliable Transports

The transmission of the payloads of a body over an unreliable transport SHOULD either all be Confirmable or all be Non-confirmable. This is meant to simplify the congestion control procedure.

As a reminder, there is no need for CoAP-specific congestion control for reliable transports [[RFC8323](#)].

6.1. Confirmable (CON)

Congestion control for CON requests and responses is specified in [Section 4.7 of \[RFC7252\]](#). For faster transmission rates, NSTART will need to be increased from 1. However, the other CON congestion control parameters will need to be tuned to cover this change. This tuning is out of scope of this document as it is expected that all requests and responses using Q-Block1 and Q-Block2 will be Non-confirmable.

It is implementation specific as to whether there should be any further requests for missing data as there will have been significant transmission failure as individual payloads will have failed after MAX_TRANSMIT_SPAN.

6.2. Non-confirmable (NON)

This document introduces new parameters MAX_PAYLOADS, NON_TIMEOUT, NON_RECEIVE_TIMEOUT, NON_MAX_RETRANSMIT, NON_PROBING_WAIT, and NON_PARTIAL_TIMEOUT primarily for use with NON (Table 4).

MAX_PAYLOADS should be configurable with a default value of 10. Both CoAP endpoints SHOULD have the same value (otherwise there will be transmission delays in one direction) and the value MAY be negotiated between the endpoints to a common value by using a higher level protocol (out of scope of this document). This is the maximum number of payloads that can be transmitted at any one time.

Note: The default value of 10 is chosen for reasons similar to those discussed in [Section 5 of \[RFC6928\]](#).

NON_TIMEOUT is the maximum period of delay between sending sets of MAX_PAYLOADS payloads for the same body. By default, NON_TIMEOUT has the same value as ACK_TIMEOUT ([Section 4.8 of \[RFC7252\]](#)).

NON_RECEIVE_TIMEOUT is the initial maximum time to wait for a missing payload before requesting retransmission for the first time. Every time the missing payload is re-requested, the time to wait value doubles. The time to wait is calculated as:

$$\text{Time-to-Wait} = \text{NON_RECEIVE_TIMEOUT} * (2 ** (\text{Re-Request-Count} - 1))$$

NON_RECEIVE_TIMEOUT has a default value of twice NON_TIMEOUT. NON_RECEIVE_TIMEOUT MUST always be greater than NON_TIMEOUT by at least one second so that the sender of the payloads has the opportunity to start sending the next set of payloads before the receiver times out.

NON_MAX_RETRANSMIT is the maximum number of times a request for the retransmission of missing payloads can occur without a response from the remote peer. After this occurs, the local endpoint SHOULD consider the body stale and remove all references to it. By default, NON_MAX_RETRANSMIT has the same value as MAX_RETRANSMIT ([Section 4.8 of \[RFC7252\]](#)).

NON_PROBING_WAIT is used to limit the potential wait needed calculated when using PROBING_WAIT. NON_PROBING_WAIT has the same value as computed for EXCHANGE_LIFETIME ([Section 4.8.2 of \[RFC7252\]](#)).

NON_PARTIAL_TIMEOUT is used for expiring partially received bodies. NON_PARTIAL_TIMEOUT has the same value as computed for EXCHANGE_LIFETIME ([Section 4.8.2 of \[RFC7252\]](#)).

Parameter Name	Default Value
MAX_PAYLOADS	10
NON_MAX_RETRANSMIT	4
NON_TIMEOUT	2 s
NON_RECEIVE_TIMEOUT	4 s
NON_PROBING_WAIT	247 s
NON_PARTIAL_TIMEOUT	247 s

Table 4: Congestion Control Parameters

PROBING_RATE parameter in CoAP indicates the average data rate that must not be exceeded by a CoAP endpoint in sending to a peer endpoint that does not respond. The single body of blocks will be subjected to PROBING_RATE ([Section 4.7 of \[RFC7252\]](#)), not the individual packets. If the wait time between sending bodies that are not being responded to based on PROBING_RATE exceeds NON_PROBING_WAIT, then the gap time is limited to NON_PROBING_WAIT.

Note: For the particular DOTS application, PROBING_RATE and other transmission parameters are negotiated between peers. Even when not negotiated, the DOTS application uses customized defaults as discussed in [Section 4.5.2 of \[RFC8782\]](#). Note that MAX_PAYLOADS, NON_MAX_RETRANSMIT, and NON_TIMEOUT can be negotiated between DOTS peers as per [\[I-D.bosh-dots-quick-blocks\]](#).

Each NON 4.08 (Request Entity Incomplete) response is subject to PROBING_RATE.

Each NON GET or FETCH request using Q-Block2 Option is subject to PROBING_RATE.

As the sending of many payloads of a single body may itself cause congestion, it is RECOMMENDED that after transmission of every set of MAX_PAYLOADS payloads of a single body, a delay is introduced of NON_TIMEOUT before sending the next set of payloads to manage potential congestion issues.

If the CoAP peer reports at least one payload has not arrived for each body for at least a 24 hour period and it is known that there are no other network issues over that period, then the value of MAX_PAYLOADS can be reduced by 1 at a time (to a minimum of 1) and the situation re-evaluated for another 24 hour period until there is no report of missing payloads under normal operating conditions. The newly derived value for MAX_PAYLOADS should be used for both ends of this particular CoAP peer link. Note that the CoAP peer will not know about the MAX_PAYLOADS change until it is reconfigured. As a consequence of not being reconfigured, the peer may indicate that there are some missing payloads prior to the actual payload being transmitted as all of its MAX_PAYLOADS payloads have not arrived.

The sending of a set of missing payloads of a body is subject to MAX_PAYLOADS set of payloads.

For Q-Block1 Option, if the server responds with a 2.31 (Continue) Response Code for the latest payload sent, then the client can continue to send the next set of payloads without any delay. If the server responds with a 4.08 (Request Entity Incomplete) Response Code, then the missing payloads SHOULD be retransmitted before going into another NON_TIMEOUT delay prior to sending the next set of payloads.

For the server receiving NON Q-Block1 requests, it SHOULD send back a 2.31 (Continue) Response Code on receipt of all of the MAX_PAYLOADS payloads to prevent the client unnecessarily delaying. Otherwise the server SHOULD delay for NON_RECEIVE_TIMEOUT (exponentially scaled based on the repeat request count for a payload), before sending the

4.08 (Request Entity Incomplete) Response Code for the missing payload(s). If this is a repeat for the 2.31 (Continue) response, the server SHOULD send a 4.08 (Request Entity Incomplete) response detailing the missing payloads after the block number that would have been indicated in the 2.31 (Continue). If the repeat request count for a missing payload exceeds NON_MAX_RETRANSMIT, the server SHOULD discard the partial body and stop requesting the missing payloads.

It is likely that the client will start transmitting the next set of MAX_PAYLOADS payloads before the server times out on waiting for the last of the previous MAX_PAYLOADS payloads. On receipt of the first received payload from the new set of MAX_PAYLOADS payloads, the server SHOULD send a 4.08 (Request Entity Incomplete) Response Code indicating any missing payloads from any previous MAX_PAYLOADS payloads. Upon receipt of the 4.08 (Request Entity Incomplete) Response Code, the client SHOULD send the missing payloads before continuing to send the remainder of the MAX_PAYLOADS payloads and then go into another NON_TIMEOUT delay prior to sending the next set of payloads.

For the client receiving NON Q-Block2 responses, it SHOULD send a 'Continue' Q-Block2 request ([Section 3.4](#)) for the next set of payloads on receipt of all of the MAX_PAYLOADS payloads to prevent the server unnecessarily delaying. Otherwise the client SHOULD delay for NON_RECEIVE_TIMEOUT (exponentially scaled based on the repeat request count for a payload), before sending the request for the missing payload(s). If the repeat request count for a missing payload exceeds NON_MAX_RETRANSMIT, the client SHOULD discard the partial body and stop requesting the missing payloads.

The server SHOULD recognize the 'Continue' Q-Block2 request as a continue request and just continue the transmission of the body (including Observe Option, if appropriate for an unsolicited response) rather than as a request for the remaining missing blocks.

It is likely that the server will start transmitting the next set of MAX_PAYLOADS payloads before the client times out on waiting for the last of the previous MAX_PAYLOADS payloads. Upon receipt of the first payload from the new set of MAX_PAYLOADS payloads, the client SHOULD send a request indicating any missing payloads from any previous set of MAX_PAYLOADS payloads. Upon receipt of such request, the server SHOULD send the missing payloads before continuing to send the remainder of the MAX_PAYLOADS payloads and then go into another NON_TIMEOUT delay prior to sending the next set of payloads.

The client does not need to acknowledge the receipt of the entire body.

Note: If there is asymmetric traffic loss causing responses to never get received, a delay of NON_TIMEOUT after every transmission of MAX_PAYLOADS blocks will be observed. The endpoint receiving the body is still likely to receive the entire body.

7. Caching Considerations

Caching block based information is not straight forward in a proxy. For Q-Block1 and Q-Block2 Options, for simplicity it is expected that the proxy will reassemble the body (using any appropriate recovery options for packet loss) before passing on the body to the appropriate CoAP endpoint. This does not preclude an implementation doing a more complex per payload caching, but how to do this is out of the scope of this document. The onward transmission of the body does not require the use of the Q-Block1 or Q-Block2 Options as these options may not be supported in that link. This means that the proxy must fully support the Q-Block1 and Q-Block2 Options.

How the body is cached in the CoAP client (for Q-Block1 transmissions) or the CoAP server (for Q-Block2 transmissions) is implementation specific.

As the entire body is being cached in the proxy, the Q-Block1 and Q-Block2 Options are removed as part of the block assembly and thus do not reach the cache.

For Q-Block2 responses, the ETag Option value is associated with the data (and onward transmitted to the CoAP client), but is not part of the cache key.

For requests with Q-Block1 Option, the Request-Tag Option is associated with the build up of the body from successive payloads, but is not part of the cache key. For the onward transmission of the body using CoAP, a new Request-Tag SHOULD be generated and used. Ideally this new Request-Tag should replace the client's request Request-Tag.

It is possible that two or more CoAP clients are concurrently updating the same resource through a common proxy to the same CoAP server using Q-Block1 (or Block1) Option. If this is the case, the first client to complete building the body causes that body to start transmitting to the CoAP server with an appropriate Request-Tag value. When the next client completes building the body, any existing partial body transmission to the CoAP server is terminated and the new body representation transmission starts with a new Request-Tag value. Note that it cannot be assumed that the proxy will always receive a complete body from a client.

A proxy that supports Q-Block2 Option MUST be prepared to receive a GET or similar request indicating one or more missing blocks. The proxy will serve from its cache the missing blocks that are available in its cache in the same way a server would send all the appropriate Q-Block2s. If the cache key matching body is not available in the cache, the proxy MUST request the entire body from the CoAP server using the information in the cache key.

How long a CoAP endpoint (or proxy) keeps the body in its cache is implementation specific (e.g., it may be based on Max-Age).

8. HTTP-Mapping Considerations

As a reminder, the basic normative requirements on HTTP/CoAP mappings are defined in [Section 10 of \[RFC7252\]](#). The implementation guidelines for HTTP/CoAP mappings are elaborated in [\[RFC8075\]](#).

The rules defined in [Section 5 of \[RFC7959\]](#) are to be followed.

9. Examples with Non-confirmable Messages

This section provides some sample flows to illustrate the use of Q-Block1 and Q-Block2 Options with NON. Examples with CON are provided in [Appendix A](#).

Figure 2 lists the conventions that are used in the following subsections.

T: Token value
O: Observe Option value
M: Message ID
RT: Request-Tag
ET: ETag
QB1: Q-Block1 Option values NUM/More/SZX
QB2: Q-Block2 Option values NUM/More/SZX
\: Trimming long lines
[[]]: Comments
-->X: Message loss (request)
X<--: Message loss (response)
...: Passage of time

Figure 2: Notations Used in the Figures

9.1. Q-Block1 Option

9.1.1. A Simple Example

Figure 3 depicts an example of a NON PUT request conveying Q-Block1 Option. All the blocks are received by the server.

```

CoAP      CoAP
Client    Server
|         |
+----->| NON PUT /path M:0x81 T:0xc0 RT=9 QB1:0/1/1024
+----->| NON PUT /path M:0x82 T:0xc1 RT=9 QB1:1/1/1024
+----->| NON PUT /path M:0x83 T:0xc2 RT=9 QB1:2/1/1024
+----->| NON PUT /path M:0x84 T:0xc3 RT=9 QB1:3/0/1024
|<-----+ NON 2.04 M:0xf1 T:0xc3
|   ...   |

```

Figure 3: Example of NON Request with Q-Block1 Option (Without Loss)

9.1.2. Handling MAX_PAYLOADS Limits

Figure 4 depicts an example of a NON PUT request conveying Q-Block1 Option. The number of payloads exceeds MAX_PAYLOADS. All the blocks are received by the server.

```

CoAP      CoAP
Client    Server
|         |
+----->| NON PUT /path M:0x01 T:0xf1 RT=10 QB1:0/1/1024
+----->| NON PUT /path M:0x02 T:0xf2 RT=10 QB1:1/1/1024
+----->| [[Payloads 3 - 9 not detailed]]
+----->| NON PUT /path M:0x0a T:0xfa RT=10 QB1:9/1/1024
[[MAX_PAYLOADS has been reached]]
|   [[MAX_PAYLOADS blocks receipt acknowledged by server]]
|<-----+ NON 2.31 M:0x81 T:0xfa
+----->| NON PUT /path M:0x0b T:0xfb RT=10 QB1:10/0/1024
|<-----+ NON 2.04 M:0x82 T:0xfb
|   ...   |

```

Figure 4: Example of MAX_PAYLOADS NON Request with Q-Block1 Option (Without Loss)

9.1.3. Handling MAX_PAYLOADS with Recovery

Consider now a scenario where a new body of data is to be sent by the client, but some blocks are dropped in transmission as illustrated in Figure 5.


```

CoAP      CoAP
Client      Server
|           |
+----->| NON PUT /path M:0x11 T:0xe1 RT=11 QB1:0/1/1024
+--->X    | NON PUT /path M:0x12 T:0xe2 RT=11 QB1:1/1/1024
+----->| [[Payloads 3 - 8 not detailed]]
+----->| NON PUT /path M:0x19 T:0xe9 RT=11 QB1:8/1/1024
+--->X    | NON PUT /path M:0x1a T:0xea RT=11 QB1:9/1/1024
[[MAX_PAYLOADS has been reached]]
|   ...   |
[[NON_TIMEOUT (client) delay expires]]
|   [[Client starts sending next set of payloads]]
+--->X    | NON PUT /path M:0x1b T:0xeb RT=11 QB1:10/1/1024
+----->| NON PUT /path M:0x1c T:0xec RT=11 QB1:11/1/1024
|           |

```

Figure 5: Example of MAX_PAYLOADS NON Request with Q-Block1 Option (With Loss)

On seeing a payload from the next set of payloads, the server realizes that some blocks are missing from the previous MAX_PAYLOADS payloads and asks for the missing blocks in one go (Figure 6). It does so by indicating which blocks from the previous MAX_PAYLOADS payloads have not been received in the data portion of the response. The token used in the response should be the token that was used in the last block number received payload. The client can then derive the Request-Tag by matching the token with the sent request.

```

CoAP      CoAP
Client      Server
|           |
|<-----+ NON 4.08 M:0x91 T:0xec [Missing 1,9]
|   [[Client responds with missing payloads]]
+----->| NON PUT /path M:0x1d T:0xed RT=11 QB1:1/1/1024
+----->| NON PUT /path M:0x1e T:0xee RT=11 QB1:9/1/1024
|   [[Client continues sending next set of payloads]]
+----->| NON PUT /path M:0x1f T:0xef RT=11 QB1:12/0/1024
|   ...   |
[[NON_RECEIVE_TIMEOUT (server) delay expires]]
|   [[The server realizes a block is still missing and asks
|       for the missing one]]
|<-----+ NON 4.08 M:0x92 T:0xef [Missing 10]
+----->| NON PUT /path M:0x20 T:0xf0 RT=11 QB1:10/1/1024
|<-----+ NON 2.04 M:0x93 T:0xf0
|   ...   |

```

Figure 6: Example of NON Request with Q-Block1 Option (Blocks Recovery)

9.1.4. Handling Recovery with Failure

Figure 7 depicts an example of a NON PUT request conveying Q-Block1 Option where recovery takes place, but eventually fails.

```

CoAP      CoAP
Client    Server
|         |
+----->| NON PUT /path M:0x91 T:0xd0 RT=12 QB1:0/1/1024
+--->X   | NON PUT /path M:0x92 T:0xd1 RT=12 QB1:1/1/1024
+----->| NON PUT /path M:0x93 T:0xd2 RT=12 QB1:2/0/1024
|   ...  |
[[NON_RECEIVE_TIMEOUT (server) delay expires]]
|   [[The server realizes a block is missing and asks
|       for the missing one.  Retry #1]]
|<-----+ NON 4.08 M:0x01 T:0xd2 [Missing 1]
|   ...  |
[[2 * NON_RECEIVE_TIMEOUT (server) delay expires]]
|   [[The server realizes a block is still missing and asks
|       for the missing one.  Retry #2]]
|<-----+ NON 4.08 M:0x02 T:0xd2 [Missing 1]
|   ...  |
[[4 * NON_RECEIVE_TIMEOUT (server) delay expires]]
|   [[The server realizes a block is still missing and asks
|       for the missing one.  Retry #3]]
|<-----+ NON 4.08 M:0x03 T:0xd2 [Missing 1]
|   ...  |
[[8 * NON_RECEIVE_TIMEOUT (server) delay expires]]
|   [[The server realizes a block is still missing and asks
|       for the missing one.  Retry #4]]
|<-----+ NON 4.08 M:0x04 T:0xd2 [Missing 1]
|   ...  |
[[16 * NON_RECEIVE_TIMEOUT (server) delay expires]]
|   [[NON_MAX_RETRANSMIT exceeded. Server stops requesting
|       for missing blocks and releases partial body]]
|   ...  |

```

Figure 7: Example of NON Request with Q-Block1 Option (With Eventual Failure)

9.2. Q-Block2 Option

These examples include the Observe Option to demonstrate how that option is used. Note that the Observe Option is not required for Q-Block2; the observe detail can thus be ignored.

9.2.1. A Simple Example

Figure 8 illustrates the example of Q-Block2 Option. The client sends a NON GET carrying Observe and Q-Block2 Options. The Q-Block2 Option indicates a block size hint (1024 bytes). This request is replied to by the server using four (4) blocks that are transmitted to the client without any loss. Each of these blocks carries a Q-Block2 Option. The same process is repeated when an Observe is triggered, but no loss is experienced by any of the notification blocks.

CoAP Client	CoAP Server
+----->	NON GET /path M:0x01 T:0xc0 0:0 QB2:0/1/1024
<-----+	NON 2.05 M:0xf1 T:0xc0 0:1220 ET=19 QB2:0/1/1024
<-----+	NON 2.05 M:0xf2 T:0xc0 0:1220 ET=19 QB2:1/1/1024
<-----+	NON 2.05 M:0xf3 T:0xc0 0:1220 ET=19 QB2:2/1/1024
<-----+	NON 2.05 M:0xf4 T:0xc0 0:1220 ET=19 QB2:3/0/1024
...	
	[[Observe triggered]]
<-----+	NON 2.05 M:0xf5 T:0xc0 0:1221 ET=20 QB2:0/1/1024
<-----+	NON 2.05 M:0xf6 T:0xc0 0:1221 ET=20 QB2:1/1/1024
<-----+	NON 2.05 M:0xf7 T:0xc0 0:1221 ET=20 QB2:2/1/1024
<-----+	NON 2.05 M:0xf8 T:0xc0 0:1221 ET=20 QB2:3/0/1024
...	

Figure 8: Example of NON Notifications with Q-Block2 Option (Without Loss)

9.2.2. Handling MAX_PAYLOADS Limits

Figure 9 illustrates the same as Figure 8 but this time has eleven (11) payloads which exceeds MAX_PAYLOADS. There is no loss experienced.


```

CoAP      CoAP
Client    Server
|         |
+----->| NON GET /path M:0x01 T:0xf0 O:0 QB2:0/1/1024
|<-----+ NON 2.05 M:0x81 T:0xf0 O:1234 ET=21 QB2:0/1/1024
|<-----+ NON 2.05 M:0x82 T:0xf0 O:1234 ET=21 QB2:1/1/1024
|<-----+ [[Payloads 3 - 9 not detailed]]
|<-----+ NON 2.05 M:0x8a T:0xf0 O:1234 ET=21 QB2:9/1/1024
[[MAX_PAYLOADS has been reached]]
|      [[MAX_PAYLOADS blocks acknowledged by client using
|      'Continue' Q-Block2]]
+----->| NON GET /path M:0x02 T:0xf1 QB2:10/1/1024
|<-----+ NON 2.05 M:0x8b T:0xf0 O:1234 ET=21 QB2:10/0/1024
|      ...      |
|      [[Observe triggered]]
|<-----+ NON 2.05 M:0x91 T:0xf0 O:1235 ET=22 QB2:0/1/1024
|<-----+ NON 2.05 M:0x92 T:0xf0 O:1235 ET=22 QB2:1/1/1024
|<-----+ [[Payloads 3 - 9 not detailed]]
|<-----+ NON 2.05 M:0x9a T:0xf0 O:1235 ET=22 QB2:9/1/1024
[[MAX_PAYLOADS has been reached]]
|      [[MAX_PAYLOADS blocks acknowledged by client using
|      'Continue' Q-Block2]]
+----->| NON GET /path M:0x03 T:0xf2 QB2:10/1/1024
|<-----+ NON 2.05 M:0x9b T:0xf0 O:1235 ET=22 QB2:10/0/1024
[[Body has been received]]
|      ...      |

```

Figure 9: Example of NON Notifications with Q-Block2 Option (Without Loss)

9.2.3. Handling MAX_PAYLOADS with Recovery

Figure 10 shows the example of an Observe that is triggered but for which some notification blocks are lost. The client detects the missing blocks and requests their retransmission. It does so by indicating the blocks that are missing as one or more Q-Block2 Options.


```

CoAP      CoAP
Client    Server
|         |
|         | [[Observe triggered]]
|<-----+ NON 2.05 M:0xa1 T:0xf0 O:1236 ET=23 QB2:0/1/1024
|         X<---+ NON 2.05 M:0xa2 T:0xf0 O:1236 ET=23 QB2:1/1/1024
|<-----+ [[Payloads 3 - 8 not detailed]]
|         X<---+ NON 2.05 M:0xaa T:0xf0 O:1236 ET=23 QB2:9/1/1024
[[MAX_PAYLOADS has been reached]]
|         |
|         | [[NON_TIMEOUT (server) delay expires]]
|         | [[Server sends next set of payloads]]
|<-----+ NON 2.05 M:0xab T:0xf0 O:1236 ET=23 QB2:10/0/1024
|         |
|         | [[NON_RECEIVE_TIMEOUT (client) delay expires]]
|         | [[Client realizes blocks are missing and asks for the
|         | missing ones in one go]]
+----->| NON GET /path M:0x04 T:0xf3 QB2:1/0/1024\
|         |                                     QB2:9/0/1024
|         X<---+ NON 2.05 M:0xac T:0xf3 ET=23 QB2:1/1/1024
|<-----+ NON 2.05 M:0xad T:0xf3 ET=23 QB2:9/1/1024
|         |
|         | [[NON_RECEIVE_TIMEOUT (client) delay expires]]
|         | [[Client realizes block is still missing and asks for
|         | missing block]]
+----->| NON GET /path M:0x05 T:0xf4 QB2:1/0/1024
|<-----+ NON 2.05 M:0xae T:0xf4 ET=23 QB2:1/1/1024
[[Body has been received]]
|         |
|         |

```

Figure 10: Example of NON Notifications with Q-Block2 Option (Blocks Recovery)

9.2.4. Handling Recovery using M-bit Set

Figure 11 shows the example of an Observe that is triggered but only the first two notification blocks reach the client. In order to retrieve the missing blocks, the client sends a request with a single Q-Block2 Option with the M bit set.


```

CoAP      CoAP
Client      Server
|          |
|  ...    |
|  [[Observe triggered]]
|<-----+ NON 2.05 M:0xb1 T:0xf0 O:1237 ET=24 QB2:0/1/1024
|<-----+ NON 2.05 M:0xb2 T:0xf0 O:1237 ET=24 QB2:1/1/1024
|  X<---+ NON 2.05 M:0xb3 T:0xf0 O:1237 ET=24 QB2:2/1/1024
|  X<---+ [[Payloads 4 - 9 not detailed]]
|  X<---+ NON 2.05 M:0xb9 T:0xf0 O:1237 ET=24 QB2:9/1/1024
[[MAX_PAYLOADS has been reached]]
|  ...    |
[[NON_TIMEOUT (server) delay expires]]
|  [[Server sends next set of payloads]]
|  X<---+ NON 2.05 M:0xba T:0xf0 O:1237 ET=24 QB2:10/0/1024
|  ...    |
[[NON_RECEIVE_TIMEOUT (client) delay expires]]
|  [[Client realizes blocks are missing and asks for the
|      missing ones in one go by setting the M bit]]
+----->| NON GET /path M:0x06 T:0xf5 QB2:2/1/1024
|<-----+ NON 2.05 M:0xbb T:0xf5 ET=24 QB2:2/1/1024
|<-----+ [[Payloads 3 - 9 not detailed]]
|<-----+ NON 2.05 M:0xc2 T:0xf5 ET=24 QB2:9/1/1024
[[MAX_PAYLOADS has been reached]]
|  [[MAX_PAYLOADS acknowledged by client using 'Continue'
|      Q-Block2]]
+----->| NON GET /path M:0x87 T:0xf6 QB2:10/1/1024
|<-----+ NON 2.05 M:0xc3 T:0xf0 O:1237 ET=24 QB2:10/0/1024
[[Body has been received]]
|  ...    |

```

Figure 11: Example of NON Notifications with Q-Block2 Option (Blocks Recovery with M bit Set)

9.3. Q-Block1 and Q-Block2 Options

9.3.1. A Simple Example

Figure 12 illustrates the example of a FETCH using both Q-Block1 and Q-Block2 Options along with an Observe Option. No loss is experienced.


```

CoAP      CoAP
Client    Server
|         |
+----->| NON FETCH /path M:0x10 T:0x90 0:0 RT=30 QB1:0/1/1024
+----->| NON FETCH /path M:0x11 T:0x91 0:0 RT=30 QB1:1/1/1024
+----->| NON FETCH /path M:0x12 T:0x93 0:0 RT=30 QB1:2/0/1024
|<-----+ NON 2.05 M:0x60 T:0x93 0:1320 ET=90 QB2:0/1/1024
|<-----+ NON 2.05 M:0x61 T:0x93 0:1320 ET=90 QB2:1/1/1024
|<-----+ NON 2.05 M:0x62 T:0x93 0:1320 ET=90 QB2:2/1/1024
|<-----+ NON 2.05 M:0x63 T:0x93 0:1320 ET=90 QB2:3/0/1024
|   ...   |
|   [[Observe triggered]]
|<-----+ NON 2.05 M:0x64 T:0x93 0:1321 ET=91 QB2:0/1/1024
|<-----+ NON 2.05 M:0x65 T:0x93 0:1321 ET=91 QB2:1/1/1024
|<-----+ NON 2.05 M:0x66 T:0x93 0:1321 ET=91 QB2:2/1/1024
|<-----+ NON 2.05 M:0x67 T:0x93 0:1321 ET=91 QB2:3/0/1024
|   ...   |

```

Figure 12: Example of NON FETCH with Q-Block1 and Q-Block2 Options
(Without Loss)

9.3.2. Handling MAX_PAYLOADS Limits

Figure 13 illustrates the same as Figure 12 but this time has eleven (11) payloads in both directions which exceeds MAX_PAYLOADS. There is no loss experienced.


```

CoAP      CoAP
Client    Server
|         |
+----->| NON FETCH /path M:0x30 T:0xa0 0:0 RT=10 QB1:0/1/1024
+----->| NON FETCH /path M:0x31 T:0xa1 0:0 RT=10 QB1:1/1/1024
+----->| [[Payloads 3 - 9 not detailed]]
+----->| NON FETCH /path M:0x39 T:0xa9 0:0 RT=10 QB1:9/1/1024
[[MAX_PAYLOADS has been reached]]
|         [[MAX_PAYLOADS blocks receipt acknowledged by server]]
|<-----+ NON 2.31 M:0x80 T:0xa9
+----->| NON FETCH /path M:0x3a T:0xaa 0:0 RT=10 QB1:10/0/1024
|<-----+ NON 2.05 M:0x81 T:0xaa 0:1334 ET=21 QB2:0/1/1024
|<-----+ NON 2.05 M:0x82 T:0xaa 0:1334 ET=21 QB2:1/1/1024
|<-----+ [[Payloads 3 - 9 not detailed]]
|<-----+ NON 2.05 M:0x8a T:0xaa 0:1334 ET=21 QB2:9/1/1024
[[MAX_PAYLOADS has been reached]]
|         [[MAX_PAYLOADS blocks acknowledged by client using
|         'Continue' Q-Block2]]
+----->| NON FETCH /path M:0x3b T:0xab QB2:10/1/1024
|<-----+ NON 2.05 M:0x8b T:0xaa 0:1334 ET=21 QB2:10/0/1024
|         ...
|         [[Observe triggered]]
|<-----+ NON 2.05 M:0x8c T:0xaa 0:1335 ET=22 QB2:0/1/1024
|<-----+ NON 2.05 M:0x8d T:0xaa 0:1335 ET=22 QB2:1/1/1024
|<-----+ [[Payloads 3 - 9 not detailed]]
|<-----+ NON 2.05 M:0x95 T:0xaa 0:1335 ET=22 QB2:9/1/1024
[[MAX_PAYLOADS has been reached]]
|         [[MAX_PAYLOADS blocks acknowledged by client using
|         'Continue' Q-Block2]]
+----->| NON FETCH /path M:0x3c T:0xac QB2:10/1/1024
|<-----+ NON 2.05 M:0x96 T:0xaa 0:1335 ET=22 QB2:10/0/1024
[[Body has been received]]
|         ...

```

Figure 13: Example of NON FETCH with Q-Block1 and Q-Block2 Options
(Without Loss)

9.3.3. Handling Recovery

Consider now a scenario where there are some blocks are lost in transmission as illustrated in Figure 14.


```

CoAP      CoAP
Client    Server
|         |
+----->| NON FETCH /path M:0x50 T:0xc0 0:0 RT=31 QB1:0/1/1024
+--->X   | NON FETCH /path M:0x51 T:0xc1 0:0 RT=31 QB1:1/1/1024
+--->X   | NON FETCH /path M:0x52 T:0xc2 0:0 RT=31 QB1:2/1/1024
+----->| NON FETCH /path M:0x53 T:0xc3 0:0 RT=31 QB1:3/0/1024
|   ...  |
[[NON_RECEIVE_TIMEOUT (server) delay expires]]

```

Figure 14: Example of NON FETCH with Q-Block1 and Q-Block2 Options
(With Loss)

The server realizes that some blocks are missing and asks for the missing blocks in one go (Figure 15). It does so by indicating which blocks have not been received in the data portion of the response. The token used in the response is be the token that was used in the last block number received payload. The client can then derive the Request-Tag by matching the token with the sent request.

```

CoAP      CoAP
Client    Server
|         |
|<-----+ NON 4.08 M:0xa0 T:0xc3 [Missing 1,2]
|         [[Client responds with missing payloads]]
+----->| NON FETCH /path M:0x54 T:0xc4 0:0 RT=31 QB1:1/1/1024
+----->| NON FETCH /path M:0x55 T:0xc5 0:0 RT=31 QB1:2/1/1024
|         [[Server received FETCH body,
|         starts transmitting response body]]
|<-----+ NON 2.05 M:0xa1 T:0xc3 0:1236 ET=23 QB2:0/1/1024
|         X<---+ NON 2.05 M:0xa2 T:0xc3 0:1236 ET=23 QB2:1/1/1024
|<-----+ NON 2.05 M:0xa3 T:0xc3 0:1236 ET=23 QB2:2/1/1024
|         X<---+ NON 2.05 M:0xa4 T:0xc3 0:1236 ET=23 QB2:3/0/1024
|   ...  |
[[NON_RECEIVE_TIMEOUT (client) delay expires]]
|         |

```

Figure 15: Example of NON Request with Q-Block1 Option (Server Recovery)

The client realizes that not all the payloads of the response have been returned. The client then asks for the missing blocks in one go (Figure 16). Note that, following [Section 2.7 of \[RFC7959\]](#), the FETCH request does not include the Q-Block1 or any payload.


```

CoAP      CoAP
Client    Server
|         |
+----->| NON FETCH /path M:0x56 T:0xc6 RT=31 QB2:1/0/1024\
|         | QB2:3/0/1024
|         | [[Server receives FETCH request for missing payloads,
|         | starts transmitting missing blocks]]
|         | X<---+ NON 2.05 M:0xa5 T:0xc6 ET=23 QB2:1/1/1024
|         | <-----+ NON 2.05 M:0xa6 T:0xc6 ET=23 QB2:3/0/1024
|         | ...
[[NON_RECEIVE_TIMEOUT (client) delay expires]]
|         | [[Client realizes block is still missing and asks for
|         | missing block]]
+----->| NON FETCH /path M:0x57 T:0xc7 RT=31 QB2:1/0/1024
|         | [[Server receives FETCH request for missing payload,
|         | starts transmitting missing block]]
|         | <-----+ NON 2.05 M:0xa7 T:0xc7 ET=23 QB2:1/1/1024
[[Body has been received]]
|         | ...
|         | [[Observe triggered]]
|         | <-----+ NON 2.05 M:0xa8 T:0xc3 O:1337 ET=24 QB2:0/1/1024
|         | X<---+ NON 2.05 M:0xa9 T:0xc3 O:1337 ET=24 QB2:1/1/1024
|         | <-----+ NON 2.05 M:0xaa T:0xc3 O:1337 ET=24 QB2:2/0/1024
[[NON_RECEIVE_TIMEOUT (client) delay expires]]
|         | [[Client realizes block is still missing and asks for
|         | missing block]]
+----->| NON FETCH /path M:0x58 T:0xc8 RT=31 QB2:1/0/1024
|         | [[Server receives FETCH request for missing payload,
|         | starts transmitting missing block]]
|         | <-----+ NON 2.05 M:0xa7 T:0xc8 ET=23 QB2:1/1/1024
[[Body has been received]]
|         | ...

```

Figure 16: Example of NON Request with Q-Block1 Option (Client Recovery)

10. IANA Considerations

10.1. New CoAP Options

IANA is requested to add the following entries to the "CoAP Option Numbers" sub-registry [[Options](#)]:

+-----+-----+-----+		
Number	Name	Reference
+=====+=====+=====+		
TBA1	Q-Block1	[RFCXXXX]
TBA2	Q-Block2	[RFCXXXX]
+-----+-----+-----+		

Table 5: CoAP Q-Block1 and Q-Block2 Option Numbers

This document suggests 19 (TBA1) and 51 (TBA2) as values to be assigned for the new option numbers.

10.2. New Media Type

This document requests IANA to register the "application/missing-blocks+cbor-seq" media type in the "Media Types" registry [[IANA-MediaTypes](#)]:

Type name: application

Subtype name: missing-blocks+cbor-seq

Required parameters: N/A

Optional parameters: N/A

Encoding considerations: binary

Security considerations: See the Security Considerations Section of [This_Document].

Interoperability considerations: N/A

Published specification: [This_Document]

Applications that use this media type: Data serialization and deserialization.

Fragment identifier considerations: N/A

Additional information:

Deprecated alias names for this type: N/A

Magic number(s): N/A

File extension(s): N/A

Macintosh file type code(s): N/A

Person & email address to contact for further information: IETF, iesg@ietf.org

Intended usage: COMMON

Restrictions on usage: none

Author: See Authors' Addresses section.

Change controller: IESG

Provisional registration? No

10.3. New Content Format

This document requests IANA to register the CoAP Content-Format ID for the "application/missing-blocks+cbor-seq" media type in the "CoAP Content-Formats" registry [[Format](#)]:

- o Media Type: application/missing-blocks+cbor-seq
- o Encoding: -
- o Id: TBA3
- o Reference: [RFCXXXX]

This document suggests 272 (TBA3) as a value to be assigned for the new content format number.

10.4. New CoAP Signaling Option Number

This document requests IANA to register the following option in the "CoAP Signaling Option Numbers" registry [CSM].

Applies to	Number	Name	Reference
7.01	TBA4	Q-Block-Wise-Transfer	[RFCXXXX]

Table 6: CoAP Signaling Option Codes

This document suggests 8 (TBA4) as a value to be assigned for the new option number.

11. Security Considerations

Security considerations discussed in [Section 7 of \[RFC7959\]](#) should be taken into account.

Security considerations discussed in Sections [11.3](#) and [11.4](#) of [\[RFC7252\]](#) should be taken into account.

OSCORE provides end-to-end protection of all information that is not required for proxy operations and requires that a security context is set up ([Section 3.1 of \[RFC8613\]](#)). It can be trusted that the source endpoint is legitimate even if NoSec security mode is used. However, an intermediary node can modify the unprotected outer Q-Block1 and/or Q-Block2 Options to cause a Q-Block transfer to fail or keep requesting all the blocks by setting the M bit and, thus, causing attack amplification. As discussed in [Section 12.1 of \[RFC8613\]](#), applications need to consider that certain message fields and messages types are not protected end-to-end and may be spoofed or manipulated. It is NOT RECOMMENDED that the NoSec security mode is used if the Q-Block1 and Q-Block2 Options are to be used.

Security considerations related to the use of Request-Tag are discussed in Section 5 of [\[I-D.ietf-core-echo-request-tag\]](#).

12. Acknowledgements

Thanks to Achim Kraus, Jim Schaad, and Michael Richardson for their comments.

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Some text from [[RFC7959](#)] is reused for readers convenience.

13. References

13.1. Normative References

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[13.2.](#) Informative References

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These examples assume NSTART has been increased to 3.

The notations provided in Figure 2 are used in the following subsections.

[A.1](#). Q-Block1 Option

Let's now consider the use Q-Block1 Option with a CON request as shown in Figure 17. All the blocks are acknowledged (ACK).


```

CoAP      CoAP
Client    Server
|         |
+----->| CON PUT /path M:0x01 T:0xf0 RT=10 QB1:0/1/1024
+----->| CON PUT /path M:0x02 T:0xf1 RT=10 QB1:1/1/1024
+----->| CON PUT /path M:0x03 T:0xf2 RT=10 QB1:2/1/1024
[[NSTART(3) limit reached]]
|<-----+ ACK 0.00 M:0x01
+----->| CON PUT /path M:0x04 T:0xf3 RT=10 QB1:3/0/1024
|<-----+ ACK 0.00 M:0x02
|<-----+ ACK 0.00 M:0x03
|<-----+ ACK 2.04 M:0x04
|         |

```

Figure 17: Example of CON Request with Q-Block1 Option (Without Loss)

Now, suppose that a new body of data is to be sent but with some blocks dropped in transmission as illustrated in Figure 18. The client will retry sending blocks for which no ACK was received.

```

CoAP      CoAP
Client    Server
|         |
+----->| CON PUT /path M:0x05 T:0xf4 RT=11 QB1:0/1/1024
+--->X   | CON PUT /path M:0x06 T:0xf5 RT=11 QB1:1/1/1024
+--->X   | CON PUT /path M:0x07 T:0xf6 RT=11 QB1:2/1/1024
[[NSTART(3) limit reached]]
|<-----+ ACK 0.00 M:0x05
+----->| CON PUT /path M:0x08 T:0xf7 RT=11 QB1:3/1/1024
|<-----+ ACK 0.00 M:0x08
|   ...   |
[[ACK_TIMEOUT (client) for M:0x06 delay expires]]
|   [[Client retransmits packet]]
+----->| CON PUT /path M:0x06 T:0xf5 RT=11 QB1:1/1/1024
[[ACK_TIMEOUT (client) for M:0x07 delay expires]]
|   [[Client retransmits packet]]
+--->X   | CON PUT /path M:0x07 T:0xf6 RT=11 QB1:2/1/1024
|<-----+ ACK 0.00 M:0x06
|   ...   |
[[ACK_TIMEOUT exponential backoff (client) delay expires]]
|   [[Client retransmits packet]]
+--->?   | CON PUT /path M:0x07 T:0xf6 RT=11 QB1:2/1/1024
|   ...   |
[[Either body transmission failure (acknowledge retry timeout)
or successfully transmitted.]]

```

Figure 18: Example of CON Request with Q-Block1 Option (Blocks Recovery)

It is up to the implementation as to whether the application process stops trying to send this particular body of data on reaching MAX_RETRANSMIT for any payload, or separately tries to initiate the new transmission of the payloads that have not been acknowledged under these adverse traffic conditions.

If there is likely to be the possibility of network transient losses, then the use of NON should be considered.

[A.2.](#) Q-Block2 Option

An example of the use of Q-Block2 Option with Confirmable messages is shown in Figure 19.


```

Client      Server
|           |
+----->| CON GET /path M:0x01 T:0xf0 O:0 QB2:0/1/1024
|<-----+ ACK 2.05 M:0x01 T:0xf0 O:1234 ET=21 QB2:0/1/1024
|<-----+ CON 2.05 M:0xe1 T:0xf0 O:1234 ET=21 QB2:1/1/1024
|<-----+ CON 2.05 M:0xe2 T:0xf0 O:1234 ET=21 QB2:2/1/1024
|<-----+ CON 2.05 M:0xe3 T:0xf0 O:1234 ET=21 QB2:3/0/1024
|----->+ ACK 0.00 M:0xe1
|----->+ ACK 0.00 M:0xe2
|----->+ ACK 0.00 M:0xe3
|   ...   |
|   [[Observe triggered]]
|<-----+ CON 2.05 M:0xe4 T:0xf0 O:1235 ET=22 QB2:0/1/1024
|<-----+ CON 2.05 M:0xe5 T:0xf0 O:1235 ET=22 QB2:1/1/1024
|<-----+ CON 2.05 M:0xe6 T:0xf0 O:1235 ET=22 QB2:2/1/1024
[[NSTART(3) limit reached]]
|----->+ ACK 0.00 M:0xe4
|<-----+ CON 2.05 M:0xe7 T:0xf0 O:1235 ET=22 QB2:3/0/1024
|----->+ ACK 0.00 M:0xe5
|----->+ ACK 0.00 M:0xe6
|----->+ ACK 0.00 M:0xe7
|   ...   |
|   [[Observe triggered]]
|<-----+ CON 2.05 M:0xe8 T:0xf0 O:1236 ET=23 QB2:0/1/1024
|   X<---+ CON 2.05 M:0xe9 T:0xf0 O:1236 ET=23 QB2:1/1/1024
|   X<---+ CON 2.05 M:0xea T:0xf0 O:1236 ET=23 QB2:2/1/1024
[[NSTART(3) limit reached]]
|----->+ ACK 0.00 M:0xe8
|<-----+ CON 2.05 M:0xeb T:0xf0 O:1236 ET=23 QB2:3/0/1024
|----->+ ACK 0.00 M:0xeb
|   ...   |
[[ACK_TIMEOUT (server) for M:0xe9 delay expires]]
|   [[Server retransmits packet]]
|<-----+ CON 2.05 M:0xe9 T:0xf0 O:1236 ET=23 QB2:1/1/1024
[[ACK_TIMEOUT (server) for M:0xea delay expires]]
|   [[Server retransmits packet]]
|   X<---+ CON 2.05 M:0xea T:0xf0 O:1236 ET=23 QB2:2/1/1024
|----->+ ACK 0.00 M:0xe9
|   ...   |
[[ACK_TIMEOUT exponential backoff (server) delay expires]]
|   [[Server retransmits packet]]
|   X<---+ CON 2.05 M:0xea T:0xf0 O:1236 ET=23 QB2:2/1/1024
|   ...   |
[[Either body transmission failure (acknowledge retry timeout)
or successfully transmitted.]]

```

Figure 19: Example of CON Notifications with Q-Block2 Option

It is up to the implementation as to whether the application process stops trying to send this particular body of data on reaching MAX_RETRANSMIT for any payload, or separately tries to initiate the new transmission of the payloads that have not been acknowledged under these adverse traffic conditions.

If there is likely to be the possibility of network transient losses, then the use of NON should be considered.

[Appendix B](#). Examples with Reliable Transports

The notations provided in Figure 2 are used in the following subsections.

[B.1](#). Q-Block1 Option

Let's now consider the use of Q-Block1 Option with a reliable transport as shown in Figure 20. There is no acknowledgment of packets at the CoAP layer, just the final result.

```

CoAP      CoAP
Client    Server
|         |
+----->| PUT /path T:0xf0 RT=10 QB1:0/1/1024
+----->| PUT /path T:0xf1 RT=10 QB1:1/1/1024
+----->| PUT /path T:0xf2 RT=10 QB1:2/1/1024
+----->| PUT /path T:0xf3 RT=10 QB1:3/0/1024
|<-----+ 2.04
|         |

```

Figure 20: Example of Reliable Request with Q-Block1 Option

If there is likely to be the possibility of network transient losses, then the use of unreliable transport with NON should be considered.

[B.2](#). Q-Block2 Option

An example of the use of Q-Block2 Option with a reliable transport is shown in Figure 21.


```

Client      Server
|           |
+----->| GET /path T:0xf0 0:0 QB2:0/1/1024
|<-----+ 2.05 T:0xf0 0:1234 ET=21 QB2:0/1/1024
|<-----+ 2.05 T:0xf0 0:1234 ET=21 QB2:1/1/1024
|<-----+ 2.05 T:0xf0 0:1234 ET=21 QB2:2/1/1024
|<-----+ 2.05 T:0xf0 0:1234 ET=21 QB2:3/0/1024
|   ...   |
|   [[Observe triggered]]
|<-----+ 2.05 T:0xf0 0:1235 ET=22 QB2:0/1/1024
|<-----+ 2.05 T:0xf0 0:1235 ET=22 QB2:1/1/1024
|<-----+ 2.05 T:0xf0 0:1235 ET=22 QB2:2/1/1024
|<-----+ 2.05 T:0xf0 0:1235 ET=22 QB2:3/0/1024
|   ...   |

```

Figure 21: Example of Notifications with Q-Block2 Option

If there is likely to be the possibility of network transient losses, then the use of unreliable transport with NON should be considered.

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