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Constrained Application Protocol (CoAP) Performance Measurement Option
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Abstract

This document specifies a method for the Performance Measurement of the Constrained Application Protocol (CoAP). A new CoAP option is defined in order to enable network telemetry. The presence of the on-path observer is also considered.

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

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1. Introduction

[RFC7252] define the CoAP Protocol. In CoAP Reliability is provided by marking a message as Confirmable (CON) with ACKs. A message that does not require reliable transmission can be sent as a Non-confirmable message (NON).

In case of CoAP reliable mode there are Message IDs and ACKs, that could eventually be used to measure Round-Trip Time (RTT) and losses. But it is resource-consuming for constrained nodes since they have to look at Message IDs and take timestamps. These operations are expensive in terms of resources. In case of CoAP unreliable mode, there is no ACK and, consequently, it is not possible to measure RTT and losses.

Thus, there is no easy way to measure the performance metrics in COAP environment to satisfy the low resources of constrained nodes. And it is in any case limited to RTT and end-to-end losses.

[I-D.mdt-ippm-explicit-flow-measurements] reported a summary on the methodologies for Explicit Flow Measurement (EFM). These EFM techniques could potentially be used in CoAP. These methodologies employ few marking bits, inside the header of each packet, for loss

and delay measurement. These are relevant for encrypted protocols, e.g. QUIC [RFC9000], where there are only few bits available in the non-encrypted header in order to allow passive performance metrics from an on-path observer.

[I-D.mdt-ippm-explicit-flow-measurements] defines different combinations of bits because the number of bits in QUIC is limited and different experiments have been done. But all these methods together imply complex algorithms that do not apply well to the CoAP environment.

This document aims to create an easy way to allow performance measurement for CoAP, by defining a new option, called Performance Measurement (PM) CoAP Option.

2. Performance Measurement methods for CoAP

CoAP [RFC7252] defines a number of options that can be included in a message. For this reason, a new option for CoAP, carrying Performance Measurement (PM) bits is the approach followed by this document.

The PM bits that are included in the Option are:

o sQuare bit (Q bit), based on [RFC8321] and further described in [I-D.mdt-ippm-explicit-flow-measurements];

o Spin bit (S bit), described in [I-D.ietf-quic-manageability] and included as optional bit in [RFC9000];

o Loss and Delay event information for further usage.

A requirement to enable PM methods in COAP environment is that the methodologies and the algorithm needs to be kept simple. For this reason, the idea is to re-apply only the S bit and Q bit.

The sQuare bit algorithm is to create square waves of a known length (e.g. 64 packets). Each side of the connection can set the Q bit and toggle its value every fixed number of packets. The number of packets can be easily recognized and packet loss can be measured.

The Spin bit algorithm is to create a square wave signal on the data flow, using a bit, whose length is equal to RTT. The Spin bit causes one bit to 'spin', generating one edge (a transition from 0 to 1 or from 1 to 0) once per end-to-end RTT. The Spin bit is set by both sides to the same value for as long as one round trip lasts and then it toggles the value.

The synergy between S bit and Q bit is also possible. As described above, the length of the Q bit square waves is fixed (e.g. a predefined number of packets) in this way each endpoint can detect a packet loss if it receives less packets than expected. In addition, it is possible to potentiate the Q bit signal by incorporating RTT information as well. This implies a little modification to the algorithm of the Q bit that could also be used alone:

> One packet in a period of the square wave can be selected and set to the opposite value of that period. After one RTT it comes back and another packet is selected and set again to the opposite value of that period. And the process can start again. By measuring the distance between these special packets it is possible to measure the RTT in addition to packet loss. The periods with the special packets have one packet less than expected but it is easy to recognize by both endpoints.

So, with one bit, it can be possible to measure loss and delay. This can be used to reinforce the Spin Bit mechanism or to use only one bit (sQuare bit) in the Option.

The advantages of using the CoAP PM Option are:

1) Simplification because it is not needed to read Message IDs, indeed there is a well-defined sQuare wave, and it is not necessary to store timestamps, since the duration of the Spin Bit period is equal to RTT.

2) Enabling easy on-path observer (proxy, gateway) metrics.

3. CoAP Performance Measurement Option

Figure 1 shows the property of the CoAP Performance Measurement (PM) Option. The formatting of this table is reported in [RFC7252]. The C, U, N, and R columns indicate the properties Critical, Unsafe, NoCacheKey, and Repeatable as defined in [RFC7252]. None of these properties is marked for the PM options.

Number	C	U	N	R	Name	Format	Length	Default
TBD					PM	uint	1	0

Figure 1: CoAP PM Option Properties

Note that it could be possible to make use of one bit in the option to identify the mode. In this way two patterns can be defined.

4. Structure of the PM Option

The value of the PM option is a 1 byte unsigned integer. This integer value encodes the following fields:

```
                         0
                         0 1 2 3 4 5 6 7
                        +-+-+-+-+-+-+-+-+
                        |M|   Pattern   |
                        +-+-+-+-+-+-+-+-+
```

Figure 2: CoAP Performance Measurement Option

Where:

- o M bit can be set to 1 or 0 and it is used to identify whether the Option follows pattern 1 (M bit = 0) or pattern 2 (M bit = 1).

- o Pattern bits can be of two kinds as reported below.

The PM Option can employ two patterns based on the value of the M bit:

```
                         0
                         0 1 2 3 4 5 6 7
                        +-+-+-+-+-+-+-+-+
                        |0|Q|   Event   |
                        +-+-+-+-+-+-+-+-+
```

Figure 3: CoAP Performance Measurement Option pattern 1

```
                         0
                         0 1 2 3 4 5 6 7
                        +-+-+-+-+-+-+-+-+
                        |1|Q|S|  Event  |
                        +-+-+-+-+-+-+-+-+
```

Figure 4: CoAP Performance Measurement Option pattern 2

The COAP Option could be defined with 2 PM bits (S and Q) or defined with a single PM bit (Q bit).

Where:

- o Q bit is used in both pattern 1 and pattern 2. It is described in [I-D.mdt-ippm-explicit-flow-measurements] and enhanced with the method described in Section 2;

- o S bit is used in Option 2. It is also embedded in the QUIC Protocol [RFC9000];

- o Event bits MAY encode additional Loss and Delay information based on well-defined encoding and they can also be used by on-path observers.

The CoAP PM Options described in this document can be used in both requests and responses. If a CoAP endpoint does not implement the measurement methodologies, it can simply leave the default value (all bits are zero). In this way the other CoAP endpoints become aware that the measurement cannot be executed in that case.

The fixed number of packets to create the Q bit signal is predefined and its value is configured from the beginning for all the CoAP endpoints.

5. On-path Observers

An on-path observer SHOULD be able to see deep into application and it can be a COAP Proxy or Gateway. The on-path observers can read Q bit and S bit and apply the relevant algorithms to measure Losses and RTT. Otherwise they can simply read the event bits and be informed about the performance without applying any algorithm. The event signaling bits can be sent from the Server (that can do the performance measurement calculation) to the Client, or viceversa.

As an example the Event bits can be divided into two parts: loss event bits and delay event bits. Based on the average RTT, an end point can define different levels of thresholds and set the delay event bits accordingly. The same applies to loss event bits. In this way an on-path observer becomes aware of the network conditions by simply reading these Event bits.

The on-path observer can read the event signaling bits and could be the Proxy or the Gateway which interconnects disjointed CoAP networks. It MAY communicate with Client and Server to set some parameters such as timeout based on the network performance.

6. Security Considerations

Security considerations related to CoAP proxying are discussed in [RFC7252].

A CoAP endpoint can use the CoAP PM Options to affect the measures of a network into which it is making requests by maliciously modifying the value of the option. Also, the PM bits may reveal performance information outside the administrative domain. To prevent that, a

CoAP proxy that is located at the boundary of an administrative domain MAY be instructed to strip the payload or part of it before forwarding the message.

7. IANA Considerations

IANA is requested to add the following entry to the "CoAP Option Numbers" sub-registry available at https://www.iana.org/assignments/core-parameters/core-parameters.xhtml#option-numbers:

Number	Name	Reference
TBD	PM Option	[This draft]

Figure 5: CoAP PM Option Numbers

8. Acknowledgements

TBD

9. References

9.1. Normative References

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9.2. Informative References

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