CoRE Working Group
Internet-Draft
Updates: 7252, 7641 (if approved)
Intended status: Standards Track
Expires: January 14, 2021

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July 13, 2020

Observe Notifications as CoAP Multicast Responses
draft-tiloca-core-observe-multicast-notifications-03

Abstract

The Constrained Application Protocol (CoAP) allows clients to "observe" resources at a server, and receive notifications as unicast responses upon changes of the resource state. In some use cases, such as based on publish-subscribe, it would be convenient for the server to send a single notification to all the clients observing a same target resource. This document defines how a CoAP server sends observe notifications as response messages over multicast, by synchronizing all the observers of a same resource on a same shared Token value. Besides, this document defines how Group OSCORE can be used to protect multicast notifications end-to-end from the CoAP server to the multiple observer clients.

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1. Introduction

The Constrained Application Protocol (CoAP) [RFC7252] has been extended with a number of mechanisms, including resource Observation [RFC7641]. This enables CoAP clients to register at a CoAP server as "observers" of a resource, and hence being automatically notified with an unsolicited response upon changes of the resource state.

CoAP supports group communication over IP multicast [I-D.ietf-core-groupcomm-bis]. This includes support for Observe registration requests over multicast, in order for clients to efficiently register as observers of a resource hosted at multiple servers.

However, in a number of use cases, using multicast messages for responses would also be desirable. That is, it would be useful that a server sends observe notifications for a same target resource to multiple observers as responses over IP multicast.

For instance, in CoAP publish-subscribe [I-D.ietf-core-coap-pubsub], multiple clients can subscribe to a topic, by observing the related resource hosted at the responsible broker. When a new value is published on that topic, it would be convenient for the broker to send a single multicast notification at once, to all the subscriber clients observing that topic.

A different use case concerns clients observing a same registration resource at the CoRE Resource Directory [I-D.ietf-core-resource-directory]. For example, multiple clients can benefit of observation for discovering (to-be-created) OSCORE groups [I-D.ietf-core-oscore-groupcomm], by retrieving from the Resource Directory updated links and descriptions to join them

through the respective Group Manager [I-D.tiloca-core-oscore-discovery].

More in general, multicast notifications would be beneficial whenever several CoAP clients observe a same target resource at a CoAP server, and can be all notified at once by means of a single response message. However, CoAP does not currently define response messages over IP multicast. This specification fills this gap and provides the following twofold contribution.

First, it defines a method to deliver Observe notifications as CoAP responses over IP multicast. In the proposed method, the group of potential observers entrusts the server to manage the Token space for multicast notifications. By doing so, the server provides all the observers of a target resource with the same Token value to bind to their own observation. That Token value is then used in every multicast notification for the target resource. This is achieved by means of an informative unicast response sent by the server to each observer client.

Second, this specification defines how to use Group OSCORE [I-D.ietf-core-oscore-groupcomm] to protect multicast notifications end-to-end between the server and the observer clients. This is also achieved by means of the informative unicast response mentioned above, which additionally includes parameter values used by the server to protect every multicast notification for the target resource by using Group OSCORE. This provides a secure binding between each of such notifications and the observation of each of the clients.

1.1. 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 are expected to be familiar with terms and concepts described in CoAP [RFC7252], group communication for CoAP [I-D.ietf-core-groupcomm-bis], Observe [RFC7641], CBOR [RFC7049], OSCORE [RFC8613], and Group OSCORE [I-D.ietf-core-oscore-groupcomm].

This specification additionally defines the following terminology.

- Traditional observation. A resource observation associated to a single observer client, as defined in [RFC7641].

- Group observation. A resource observation associated to a group of clients. The server sends notifications for the group-observed resource over IP multicast to all the observer clients.

- Phantom request. The CoAP request message that the server would have received to generate a group observation on one of its resources. The phantom request is generated inside the server and does not hit the wire.

- Informative response. A CoAP response message that the server sends to a given client via unicast, providing the client with information on a group observation.

2. Server-Side Requirements

The server can, at any time, start a group observation on one of its resources. Practically, the server may want to do that under the following circumstances.

- In the absence of observations for the target resource, the server receives a registration request from a first client wishing to start a traditional observation on that resource.

- When a certain amount of traditional observations has been established on the target resource, the server decides to make those clients part of a group observation on that resource.

The server maintains an observer counter for each group observation to a target resource, as a rough estimation of the observers actively taking part in the group observation.

The server initializes the counter to 0 when starting the group observation, and increments it after a new client starts taking part in that group observation. Also, the server should keep the counter up-to-date over time, for instance by using the method described in Section 2.5.1.

2.1. Request

Assuming it is reachable at the address SERVER_ADDR and port number SERVER_PORT, the server starts a group observation on one of its resources as defined below. The server intends to send multicast notifications for the target resource to the multicast IP address GROUP_ADDR and port number GROUP_PORT.

1. The server builds a phantom observation request, i.e. a GET request with an Observe option set to 0 (register).

2. The server selects an available value T, from the Token space of a CoAP endpoint used for messages having:

   * As source address and port number, the IP multicast address GROUP_ADDR and port number GROUP_PORT.

   * As destination address and port number, the server address SERVER_ADDR and port number SERVER_PORT, intended for accessing the target resource.

   This Token space is under exclusive control of the server.

3. The server processes the phantom observation request above, without transmitting it on the wire. The request is addressed to the resource for which the server wants to start the group observation, as if sent from the group of observers, i.e. with GROUP_ADDR as source address and GROUP_PORT as source port.

4. Upon processing the self-generated phantom request, the server interprets it as an observe registration received from the group of potential observer clients. In particular, from then on, the server MUST use T as its own local Token value associated to that observation, with respect to the (next hop towards the) clients.

5. The server does not immediately respond to the phantom observation request with a multicast notification sent on the wire. The server stores the phantom observation request as is, throughout the lifetime of the group observation.

6. The server builds a CoAP response message INIT_NOTIF as initial multicast notification for the target resource, in response to the phantom observation request. This message is formatted as other multicast notifications (see Section 2.3) and MUST include the current representation of the target resource as payload. The server stores the message INIT_NOTIF and does not transmit it. The server considers this message as the latest multicast notification for the target resource, until it transmits a new multicast notification for that resource as a CoAP message on the wire. After that, the server deletes the message INIT_NOTIF.

2.2. Informative Response

After having started a group observation on a target resource, the server proceeds as follows.

For each traditional observation ongoing on the target resource, the server MAY cancel that observation. Then, the server considers the N

corresponding clients as now taking part in the group observation, of which it increases the corresponding observer counter by N.

The server sends to each of such clients an informative response message, encoded as a unicast response with response code 5.03 (Service Unavailable). As per [RFC7641], such a response does not include an Observe option. The response MUST be Confirmable and MUST NOT encode link-local addresses.

The Content-Format of the informative response is set to application/informative-response+cbor, as defined in Section 9.2. The payload of the informative response is a CBOR map which MUST include all the following parameters, whose CBOR labels are defined in Section 7.

- 'ph_req', with value the byte serialization of the CoAP message received by the server as phantom observation request (see Section 2.1), encoded as a CBOR byte string. Specifically, the value of the byte string is the byte serialization of what intended as payload for the transport layer underlying CoAP.

- 'last_notif', with value the byte serialization of the CoAP message stored by the server as the latest multicast notification for the target resource, encoded as a CBOR byte string. Specifically, the value of the byte string is the byte serialization of what intended as payload for the transport layer underlying CoAP.

- 'cli_addr', with value the source IP address of the phantom observation request, encoded as a CBOR byte string. This parameter is tagged and identified by the CBOR tag 260 "Network Address (IPv4 or IPv6 or MAC Address)". The specified value is the IP multicast address GROUP_ADDR, where the server will send multicast notifications for the target resource.

- 'cli_port', with value the source port number of the phantom observation request, encoded as a CBOR unsigned integer. The specified value is the port number GROUP_PORT, where the server will send multicast notifications for the target resource.

- 'srv_addr', with value the destination IP address of the phantom observation request, encoded as a CBOR byte string. This parameter is tagged and identified by the CBOR tag 260 "Network Address (IPv4 or IPv6 or MAC Address)". The specified value is the IP address SERVER_ADDR of the server hosting the target resource.

- 'srv_port', with value the destination port number of the phantom observation request, encoded as a CBOR unsigned integer. The

specified value is the port number SERVER_PORT of the server hosting the target resource has been listening to.

Upon receiving a registration request to observe the target resource, the server does not create a corresponding individual observation for the requesting client. Instead, the server considers that client as now taking part in the group observation of the target resource, of which it increments the observer counter by 1. Then, the server replies to the client with the same informative response message defined above, which MUST be Confirmable and MUST include also the 'last_notif' parameter.

Note that this also applies when, with no ongoing traditional observations on the target resource, the server receives a registration request from a first client and decides to start a group observation on the target resource.

2.3. Notifications

Upon a change of the status of the target resource under group observation, the server sends a multicast notification, intended to all the clients taking part in the group observation of that resource. In particular, each of such multicast notifications is formatted as follows.

- It MUST be Non-confirmable.
- It MUST include an Observe option, as per [RFC7641].
- It MUST have the same Token value T of the phantom registration request that started the group observation, also specified in the 'ph_req' parameter of the informative response message to the observer clients. That is, every multicast notification for a target resource is not bound to the observation requests from the different clients, but rather to the phantom registration request associated to the whole set of clients taking part in the group observation of that resource.

The server sends a multicast notification to the IP multicast address GROUP_ADDR and port number GROUP_PORT indicated to the observer clients, as value of the 'cli_addr' and 'cli_port' parameters of the informative response message (see Section 2.2).

For each target resource with an active group observation, the server MUST store the latest multicast notification.

2.4. Congestion Control

In order to not cause congestion, the server should conservatively control the sending of multicast notifications. In particular:

- The multicast notifications MUST be Non-confirmable.

- In constrained environments such as low-power, lossy networks (LLNs), the server should only support multicast notifications for resources that are small. Following related guidelines from Section 2.2.4 of [I-D.ietf-core-groupcomm-bis], this can consist, for example, in having the payload of multicast notifications as limited to approximately 5% of the IP Maximum Transmit Unit (MTU) size, so that it fits into a single link-layer frame in case IPv6 over Low-Power Wireless Personal Area Networks (6LoWPAN) (see Section 4 of [RFC4944]) is used.

- The server SHOULD provide multicast notifications with the smallest possible IP multicast scope that fulfills the application needs. For example, following related guidelines from Section 2.2.4 of [I-D.ietf-core-groupcomm-bis], site-local scope is always preferred over global scope IP multicast, if this fulfills the application needs. Similarly, realm-local scope is always preferred over site-local scope, if this fulfills the application needs.

- Following related guidelines from Section 4.5.1 of [RFC7641], the server SHOULD NOT send more than one multicast notification every 3 seconds, and SHOULD use an even less aggressive rate when possible (see also Section 3.1.2 of [RFC8085]). The transmission rate of multicast notifications should also take into account the avoidance of a possible "broadcast storm" problem [MOBICOM99]. This prevents a following, considerable increase of the channel load, whose origin would be likely attributed to a router rather than the server.

2.5. Cancellation

At any point in time, the server may want to cancel a group observation of a target resource. For instance, the server may realize that no clients or not enough clients are interested in taking part in the group observation anymore. A possible approach that the server can use to assess this is defined in Section 2.5.1.

In order to cancel the group observation, the server sends to itself a phantom cancellation request, i.e. a GET request with an Observe option set to 1 (deregister), without transmitting it on the wire. As per Section 3.6 of [RFC7641], all other options MUST be identical

to those in the phantom registration request, except for the set of ETag Options. This request has the same Token value T of the phantom registration request, and is addressed to the resource for which the server wants to end the group observation, as if sent from the group of observers, i.e. with the multicast IP address GROUP_ADDR as source address and the port number GROUP_PORT as source port.

After that, the server sends a multicast response with response code 5.03 (Service Unavailable), signaling that the group observation has been terminated. The response has no payload, and is sent to the same multicast IP address GROUP_ADDR and port number GROUP_PORT used to send the multicast notifications related to the target resource. As per [RFC7641], this response does not include an Observe option. Finally, the server releases the resources allocated for the group observation, and especially frees up the Token value T used at its CoAP endpoint.

2.5.1. Rough Counting of Clients in the Group Observation

To allow the server to keep an estimate of interested clients without creating undue traffic on the network, a new CoAP option is introduced, which SHOULD be supported by clients that listen to multicast responses.

The option is called Multicast-Response-Feedback-Divider, and is only used in responses. As summarized in Figure 1, the option is not critical but proxy-unsafe, and integer valued.

No.	C	U	N	R	Name	Format	Len.	Default
TBD		x			Multicast-Response-Feedback-Divider	uint	0-8 B	(none)

C = Critical, U = Unsafe, N = NoCacheKey, R = Repeatable,

Figure 1: Multicast-Response-Feedback-Divider

The Multicast-Response-Feedback-Divider option is of class E for OSCORE [RFC8613][I-D.ietf-core-oscore-groupcomm].

2.5.1.1. Client Processing

Upon receiving a response with a Multicast-Response-Feedback-Divider option, a client SHOULD acknowledge its interest in continuing receiving multicast notifications for the target resource, as described below.

The client picks an integer random number I, from 0 inclusive to the number Q given in the option exclusive. If I is different than 0, the client takes no further action. Otherwise, the client should wait a random fraction of the Leisure time (see Section 8.2 of [RFC7252]), and then registers a regular unicast observation on the same target resource.

To this end, the client essentially follows the steps that got it originally subscribed to group notifications for the target resource. In particular, the client sends an observation request to the server, i.e. a GET request with an Observe option set to 0 (register). The request MUST be addressed to the same target resource, and MUST have the same destination IP address and port number used for the original registration request, regardless the source IP address and port number of the received multicast notification.

As the observation registration is only done for its side effect of showing as an attempted observation at the server, the client MUST send the unicast request in a non confirmable way, and with the maximum No-Response setting [RFC7967]. In the request, the client MUST include a Multicast-Response-Feedback-Divider option, whose value MUST be empty (Option Length = 0). The client does not need to wait for responses, and can keep processing further notifications on the same token.

The client MUST ignore the Multicast-Response-Feedback-Divider option, if the multicast notification is retrieved from the 'last_notif' parameter of an informative response (see Section 2.2). A client includes the Multicast-Response-Feedback-Divider option only in a re-registration request triggered by the server as described above, and MUST NOT include it in any other request.

As the Multicast-Response-Feedback-Divider option is unsafe to forward, a proxy needs to answer it on its own, and is later counted as a single client.

Appendix A.1 provides a description in pseudo-code of the operations above performed by the client.

2.5.1.2. Client Counting

In order to avoid needless use of network resources, a server SHOULD keep a rough count of the number of clients taking part in the group observation of a target resource. To this end, the server updates the associated observer counter (see Section 2), for instance by using the method described below.

When it wants to obtain a new estimated count, the server picks a number M of confirmations it would like to receive from the clients. It is up to applications to define policies about how the server determines and adjusts the value of M. The following example will be done with M = 5.

Then, the server considers its current estimate of listeners N, and divides it by M. The resulting quotient Q = ceil(N / M) is set as value in the Multicast-Response-Feedback-Divider option, which is sent within a successful multicast notification. If several multicast notifications are sent in a burst fashion, it is RECOMMENDED for the server to include the Multicast-Response-Feedback-Divider option only in the first one of those notifications.

The server collects unicast observation requests from the clients, for an amount of time of MAX_CONFIRMATION_WAIT seconds. The server MUST NOT update the observer counter N associated to the group observation, until MAX_CONFIRMATION_WAIT seconds have elapsed.

It is up to applications to define the value of MAX_CONFIRMATION_WAIT, which has to take into account the transmission time of the multicast notification and of unicast observation requests, as well as the leisure time of the clients, which may be hard to know or estimate for the server.

If this information is not known to the server, it is recommended to define MAX_CONFIRMATION_WAIT as follows.

MAX_CONFIRMATION_WAIT = MAX_RTT + MAX_CLIENT_REQUEST_DELAY

where MAX_RTT is as defined in Section 4.8.2 of [RFC7252] and has default value 202 seconds, while MAX_CLIENT_REQUEST_DELAY is equivalent to MAX_SERVER_RESPONSE_DELAY defined in Section 2.3.1 of [I-D.ietf-core-groupcomm-bis] and has default value 250 seconds. In the absence of more specific information, the server can thus consider a conservative MAX_CONFIRMATION_WAIT of 452 seconds.

If more information is available in deployments, a much shorter MAX_CONFIRMATION_WAIT can be set, based on a realistic round trip time (replacing MAX_RTT) and on the largest leisure time configured on the clients (e.g. DEFAULT_LEISURE = 5 replacing MAX_CLIENT_REQUEST_DELAY), thus shortening MAX_CONFIRMATION_WAIT to a few seconds.

Once MAX_CONFIRMATION_WAIT seconds have passed, the server counts the R confirmations arrived as unicast observation requests to the target resource, after the multicast notification has been sent. In particular, the server considers a unicast observation request as a

confirmation from a client only if it includes a Multicast-Response-Feedback-Divider option with an empty value (Option Length = 0). Then, the server multiplies R by the original Multicast-Response-Feedback-Divider value Q, to get an updated client estimate.

If X new clients are added to the group observation while the process above is occurring, the server MUST first complete the counting process and update N based on the received re-registration requests. Only after that, the server further increments N by X, and considers the result as the current observer counter to assess for possibly cancelling the group observation (see Section 2.5).

This estimate is skewed by packet loss, but it gives the server a sufficiently good estimation for further counts and for deciding when to cancel the group observation. It is up to applications to define policies about how the server takes the updated value of N into account and determines whether to cancel the group observation.

As an example, if the server currently estimates that N = 20 observers are active, it sends a notification out with Multicast-Response-Feedback-Divider: 4. Then, out of 18 actually active clients, 5 send a re-registration request based on their random draw, of which one request gets lost, thus leaving four re-registration requests received by the server. Also, no new clients have been added to the group observation in the meanwhile. As a consequence, the server updates the observer counter to N = (4 * 4) + 0 = 16, and continues sending notifications to the group of observers.

Note that a server can send Multicast-Response-Feedback-Divider: 1 in the last notifications, before cancelling a group observation. This will trigger all the active clients to state their interest in continuing receiving notifications for the target resource.

Appendix A.2 provides a description in pseudo-code of the operations above performed by the server.

3. Client-Side Requirements

3.1. Request

A client sends an observation request to the server as described in [RFC7641], i.e. a GET request with an Observe option set to 0 (register). The request MUST NOT encode link-local addresses. If the server is not configured to accept registrations on that target resource with a group observation, this would still result in a positive notification response to the client as described in [RFC7641].

3.2. Informative Response

Upon receiving the informative response defined in Section 2.2, the client proceeds as follows.

1. The client configures an observation of the target resource. To this end, it relies on a CoAP endpoint used for messages having:

   * As source address and port number, the server address SERVER_ADDR and port number SERVER_PORT intended for accessing the target resource.

   * As destination address and port number, the IP multicast address GROUP_ADDR and port number GROUP_PORT, specified in the 'cli_addr' and 'cli_port' parameter.

2. The client retrieves and stores the phantom registration request specified in the 'ph_req' parameter. The group observation is bound to this phantom registration request. In particular, the client MUST use its Token value T as its own local Token value associated to that group observation, with respect to the (next hop towards the) server. The particular way to achieve this is implementation specific.

3. The client retrieves the multicast notification specified in the 'last_notif' parameter, and processes it as defined in Section 3.2 of [RFC7641]. In particular, the value of the Observe option is used as initial baseline for notification reordering in this group observation.

4. If a traditional observation to the target resource is ongoing, the client MAY silently cancel it without notifying the server.

If any of the expected fields are not present, the client MAY try sending a new registration request to the server (see Section 3.1). Otherwise, the client SHOULD explicitly withdraw from the group observation.

Appendix B describes possible alternative ways for clients to retrieve the phantom request and other information related to a group observation.

3.3. Notifications

After having successfully processed the informative response as defined in Section 3.2, the client will receive, accept and process multicast notifications about the state of the target resource from

the server, as responses to the phantom registration request and with Token value T.

The client relies on the value of the Observe option for notification reordering, as defined in Section 3.4 of [RFC7641].

3.4. Cancellation

At a certain point in time, a client may become not interested in receiving further multicast notifications about a target resource. When this happens, the client can simply "forget" about being part of the group observation for that target resource, as per Section 3.6 of [RFC7641].

When, later on, the server sends the next multicast notification, the client will not recognize the Token value T in the message. Since the multicast notification is Non-confirmable, it is OPTIONAL for the client to reject the multicast notification with a Reset message, as defined in Section 3.5 of [RFC7641].

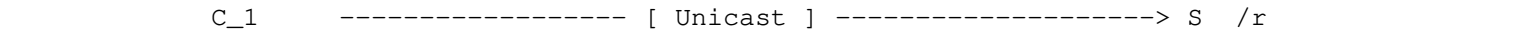
In case the server has cancelled a group observation as defined in Section 2.5, the client simply forgets about the group observation and frees up the used Token value T for that endpoint, upon receiving the multicast error response defined in Section 2.5.

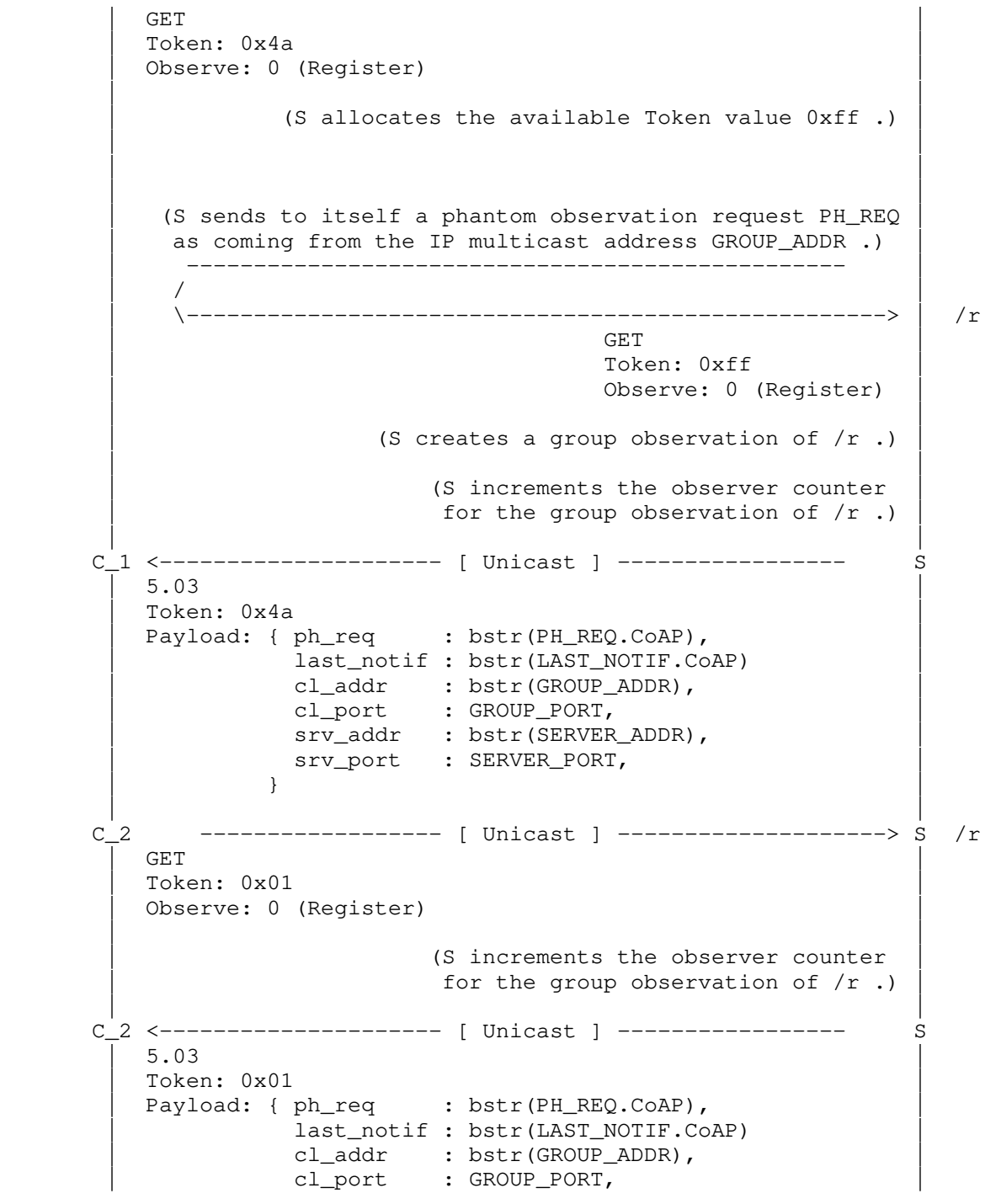
4. Example

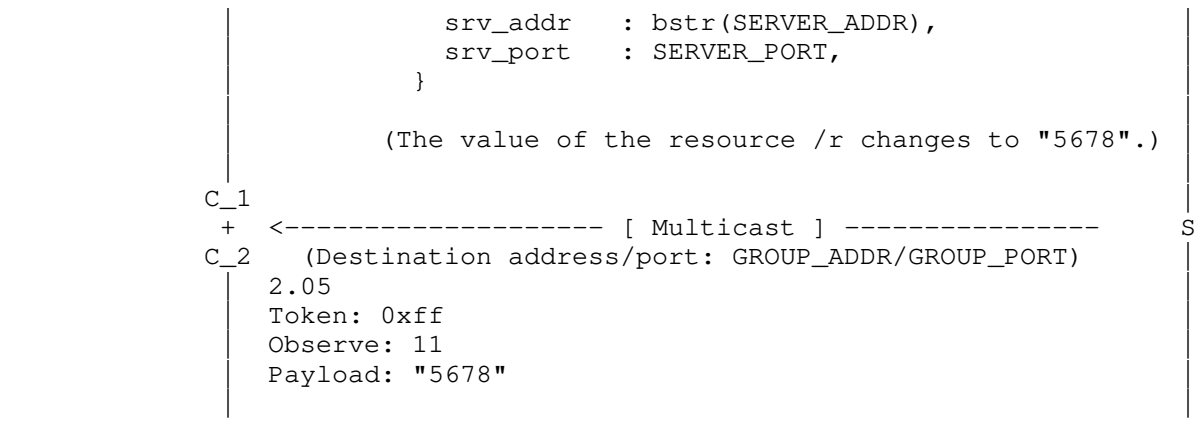
The following example refers to two clients C_1 and C_2 that register to observe a resource /r at a Server S with address SERVER_ADDR and listening to the port number SERVER_PORT. Before the following exchanges occur, no clients are observing the resource /r , which has value "1234".

In the informative responses, 'bstr(X)' denotes a byte string with value the byte serialization of X. Also, the notation Y.CoAP denotes the CoAP-layer part of a message Y, i.e. the part of Y that becomes payload for the transport layer underlying CoAP.

The server S sends multicast notifications to the IP multicast address GROUP_ADDR and port number GROUP_PORT, and starts the group observation upon receiving a registration request from a first client that wishes to start a traditional observation on the resource /r.




GET
Token: 0x4a
Observe: 0 (Register)
(S allocates the available Token value 0xff .)
(S sends to itself a phantom observation request PH_REQ
as coming from the IP multicast address GROUP_ADDR .)
/r
GET
Token: 0xff
Observe: 0 (Register)
(S creates a group observation of /r .)
(S increments the observer counter
for the group observation of /r .)
C_1
[Unicast]
S
5.03
Token: 0x4a
Payload: { ph_req : bstr(PH_REQ.CoAP),
last_notif : bstr(LAST_NOTIF.CoAP)
cl_addr : bstr(GROUP_ADDR),
cl_port : GROUP_PORT,
srv_addr : bstr(SERVER_ADDR),
srv_port : SERVER_PORT,
}
C_2
[Unicast]
S
/r
GET
Token: 0x01
Observe: 0 (Register)
(S increments the observer counter
for the group observation of /r .)
C_2
[Unicast]
S
5.03
Token: 0x01
Payload: { ph_req : bstr(PH_REQ.CoAP),
last_notif : bstr(LAST_NOTIF.CoAP)
cl_addr : bstr(GROUP_ADDR),
cl_port : GROUP_PORT,



5. Protection of Multicast Notifications with Group OSCORE

A server can protect multicast notifications by using Group OSCORE [I-D.ietf-core-oscore-groupcomm]. Both the server and the clients interested in receiving multicast notifications from that server have to be members of the same OSCORE group.

Clients MAY discover the OSCORE group to refer to by using the method in [I-D.tiloca-core-oscore-discovery], based on the CoRE Resource Directory (RD) [I-D.ietf-core-resource-directory]. Alternatively, the server MAY communicate to the client what OSCORE group to join, as described in Section 5.1. Furthermore, both the clients and the server MAY join the OSCORE group by using the approach described in [I-D.ietf-ace-key-groupcomm-oscore] and based on the ACE framework for Authentication and Authorization in constrained environments [I-D.ietf-ace-oauth-authz]. Further details on how to discover the OSCORE group and join it are out of the scope of this specification.

Alternative security protocols than Group OSCORE, such as OSCORE [RFC8613] and/or DTLS [RFC6347][I-D.ietf-tls-dtls13], can be used to protect other exchanges via unicast between the server and each client, including the original client registration (see Section 3).

5.1. Signaling the OSCORE Group in the Informative Response

This section describes a mechanism for the server to communicate to the client what OSCORE group to join in order to decrypt and verify the multicast notifications protected with group OSCORE. The client MAY use the information provided by the server to start the ACE joining procedure described in [I-D.ietf-ace-key-groupcomm-oscore]. This mechanism is OPTIONAL to support for the client and server.

Additionally to what defined in Section 2, the CBOR map in the informative response payload contains the following fields, whose CBOR labels are defined in Section 7.

- 'join_uri', with value the URI for joining the OSCORE group at the respective Group Manager, encoded as a CBOR text string. If the procedure described in [I-D.ietf-ace-key-groupcomm-oscore] is used for joining, this field specifically indicates the URI of the group-membership resource at the Group Manager.

- 'sec_gp', with value the name of the OSCORE group, encoded as a CBOR text string.

- Optionally, 'as_uri', with value the URI of the Authorization Server associated to the Group Manager for the OSCORE group, encoded as a CBOR text string.

- Optionally, 'cs_alg', with value the COSE algorithm [I-D.ietf-cose-rfc8152bis-algs] used to countersign messages in the OSCORE group, encoded as a CBOR text string or integer. The value is taken from the 'Value' column of the "COSE Algorithms" Registry [COSE.Algorithms].

- Optionally, 'cs_alg_crv', with value the elliptic curve (if applicable) for the COSE algorithm [I-D.ietf-cose-rfc8152bis-algs] used to countersign messages in the OSCORE group, encoded as a CBOR text string or integer. The value is taken from the 'Value' column of the "COSE Elliptic Curve" Registry [COSE.Elliptic.Curves].

- Optionally, 'cs_key_kty', with value the COSE key type [I-D.ietf-cose-rfc8152bis-struct] of countersignature keys used to countersign messages in the OSCORE group, encoded as a CBOR text string or a integer. The value is taken from the 'Value' column of the "COSE Key Types" Registry [COSE.Key.Types].

- Optionally, 'cs_key_crv', with value the elliptic curve (if applicable) of countersignature keys used to countersign messages in the OSCORE group, encoded as a CBOR text string or integer. The value is taken from the 'Value' column of the "COSE Elliptic Curve" Registry [COSE.Elliptic.Curves].

- Optionally, 'cs_kenc', with value the encoding of the public keys used in the OSCORE group, encoded as a CBOR integer. The value is taken from the 'Confirmation Key' column of the "CWT Confirmation Method" registry defined in [RFC8747]. Future specifications may define additional values for this parameter.

- Optionally, 'alg', with value the COSE AEAD algorithm [I-D.ietf-cose-rfc8152bis-algs], encoded as a CBOR text string or integer. The value is taken from the 'Value' column of the "COSE Algorithms" Registry [COSE.Algorithms].

- Optionally, 'hkdf', with value the COSE HKDF algorithm [I-D.ietf-cose-rfc8152bis-algs], encoded as a CBOR text string or integer. The value is taken from the 'Value' column of the "COSE Algorithms" Registry [COSE.Algorithms].

The values of 'cs_alg', 'cs_alg_crv', 'cs_key_kty', 'cs_key_crv' and 'cs_key_kenc' provide an early knowledge of the format and encoding of public keys used in the OSCORE group. Thus, the client does not need to ask the Group Manager for this information as a preliminary step before the (ACE) join process, or to perform a trial-and-error exchange with the Group Manager upon joining the group. Hence, the client is able to provide the Group Manager with its own public key in the correct expected format and encoding, at the very first step of the (ACE) join process.

The values of 'cs_alg', 'alg' and 'hkdf' provide an early knowledge of the algorithms used in the OSCORE group. Thus, the client is able to decide whether to actually proceed with the (ACE) join process, depending on its support for the indicated algorithms.

As mentioned above, since this mechanism is OPTIONAL, all the fields are OPTIONAL in the informative response. However, the 'join_uri' and 'sec_gp' fields MUST be present if the mechanism is implemented and used. If any of the fields are present without the 'join_uri' and 'sec_gp' fields present, the client MUST ignore these fields, since they would not be sufficient to start the (ACE) join procedure. When this happens, the client MAY try sending a new registration request to the server (see Section 3.1). Otherwise, the client SHOULD explicitly withdraw from the group observation.

5.2. Server-Side Requirements

When using Group OSCORE to protect multicast notifications, the server performs the operations described in Section 2, with the following differences.

5.2.1. Registration

The phantom registration request MUST be secured, by using Group OSCORE. In particular, the group mode of Group OSCORE defined in Section 8 of [I-D.ietf-core-oscore-groupcomm] MUST be used.

The server protects the phantom registration request as defined in Section 8.1 of [I-D.ietf-core-oscore-groupcomm], as if it was the actual sender, i.e. by using its Sender Context. As a consequence, the server consumes the current value of its Sender Sequence Number SN in the OSCORE group, and hence updates it to SN* = (SN + 1). Consistently, the OSCORE option in the phantom registration request includes:

- As 'kid', the Sender ID of the server in the OSCORE group.

- As 'piv', the previously consumed sender sequence number value SN of the server in the OSCORE group, i.e. (SN* - 1).

5.2.2. Informative Response

The phantom observation request specified in the 'ph_req' parameter is protected with Group OSCORE (see Section 5.2.1).

The multicast notification specified in the 'last_notif' parameter is also protected with Group OSCORE, just like for the multicast notifications transmitted as CoAP messages on the wire (see Section 5.2.3). This applies also to the initial multicast notification INIT_NOTIF built in step 6 of Section 2.1.

Optionally, the informative response includes information on the OSCORE group to join, as additional parameters (see Section 5.1).

5.2.3. Notifications

The server MUST protect every multicast notification for the target resource with Group OSCORE. In particular, the group mode of Group OSCORE defined in Section 8 of [I-D.ietf-core-oscore-groupcomm] MUST be used.

The process described in Section 8.3 of [I-D.ietf-core-oscore-groupcomm] applies, with the following additions when building the two OSCORE 'external_aad' to encrypt and countersign the multicast notification (see Sections 4.3.1 and 4.3.2 of [I-D.ietf-core-oscore-groupcomm]).

- The 'request_kid' is the 'kid' value in the OSCORE option of the phantom registration request, i.e. the Sender ID of the server.

- The 'request_piv' is the 'piv' value in the OSCORE option of the phantom registration request, i.e. the consumed sender sequence number SN of the server.

Note that these same values are used to protect each and every multicast notification sent for the target resource.

5.2.4. Cancellation

When cancelling a group observation (see Section 2.5), the phantom cancellation request MUST be secured, by using Group OSCORE. In particular, the group mode of Group OSCORE defined in Section 8 of [I-D.ietf-core-oscore-groupcomm] MUST be used.

Like defined in Section 5.2.1 for the phantom registration request, the server protects the phantom cancellation request as per Section 8.1 of [I-D.ietf-core-oscore-groupcomm], by using its Sender Context and consuming its current Sender Sequence number in the OSCORE group, from its Sender Context. The following, corresponding multicast error response defined in Section 2.5 is also protected with Group OSCORE, as per Section 8.3 of [I-D.ietf-core-oscore-groupcomm].

Note that, differently from the multicast notifications, this multicast error response will be the only one securely paired with the phantom cancellation request.

5.3. Client-Side Requirements

When using Group OSCORE to protect multicast notifications, the client performs as described in Section 3, with the following differences.

5.3.1. Informative Response

Upon receiving the informative response from the server, the client retrieves the phantom registration request specified in the 'ph_req' parameter.

Then, the client decrypts and verifies the phantom registration request as defined in Section 8.2 of [I-D.ietf-core-oscore-groupcomm], with the following differences.

- The client MUST NOT perform any replay check. That is, the client skips step 3 in Section 8.2 of [RFC8613].

- If decryption and verification of the phantom registration request succeed:

  * The client MUST NOT update the Replay Window in the Recipient Context associated to the server. That is, the client skips the second bullet of step 6 in Section 8.2 of [RFC8613].

* The client MUST NOT take any further process as normally expected according to [RFC7252]. That is, the client skips step 8 in Section 8.2 of [RFC8613]. In particular, the client MUST NOT deliver the phantom registration request to the application, and MUST NOT take any action in the Token space of its unicast endpoint, where the informative response has been received.

* The client stores the values of the 'kid' and 'piv' fields from the OSCORE option of the phantom registration request.

The client also decrypts and verifies the multicast notification specified in the 'last_notif' parameter, just like for the multicast notifications transmitted as CoAP messages on the wire (see Section 5.3.2).

5.3.2. Notifications

After having successfully processed the informative response as defined in Section 5.3.1, the client will decrypt and verify every multicast notification for the target resource as defined in Section 8.4 of [I-D.ietf-core-oscore-groupcomm], with the following difference.

The client MUST set the two 'external_aad' defined in Sections 4.3.1 and 4.3.2 of [I-D.ietf-core-oscore-groupcomm] as follows. The particular way to achieve this is implementation specific.

- 'request_kid' takes the value of the 'kid' field from the OSCORE option of the phantom registration request (see Section 5.3.1).

- 'request_piv' takes the value of the 'piv' field from the OSCORE option of the phantom registration request (see Section 5.3.1).

Note that these same values are used to decrypt and verify each and every multicast notification received for the target resource.

The replay protection and checking of multicast notifications is performed as specified in Section 4.1.3.5.2 of [RFC8613].

6. Example with Group OSCORE

The following example refers to two clients C_1 and C_2 that register to observe a resource /r at a Server S with address SERVER_ADDR and listening to the port number SERVER_PORT. Before the following exchanges occur, no clients are observing the resource /r , which has value "1234".

In the informative responses, 'bstr(X)' denotes a byte string with value the byte serialization of X. Also, the notation Y.CoAP denotes the CoAP-layer part of a message Y, i.e. the part of Y that becomes payload for the transport layer underlying CoAP.

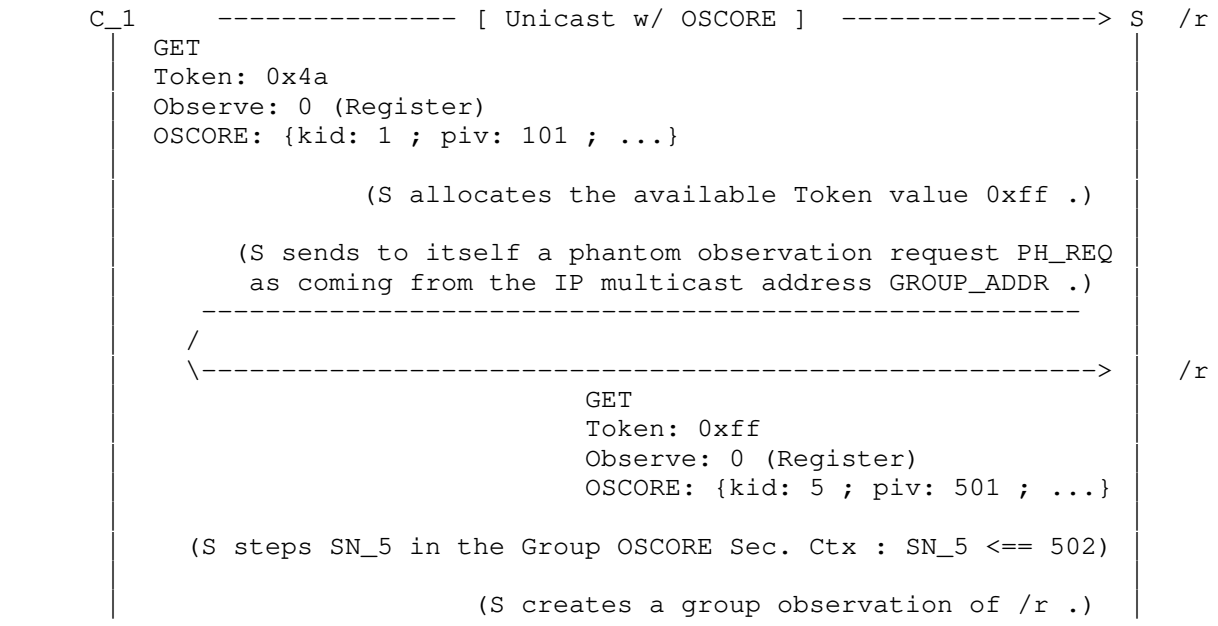
The server S sends multicast notifications to the IP multicast address GROUP_ADDR and port number GROUP_PORT, and starts the group observation upon receiving a registration request from a first client that wishes to start a traditional observation on the resource /r.

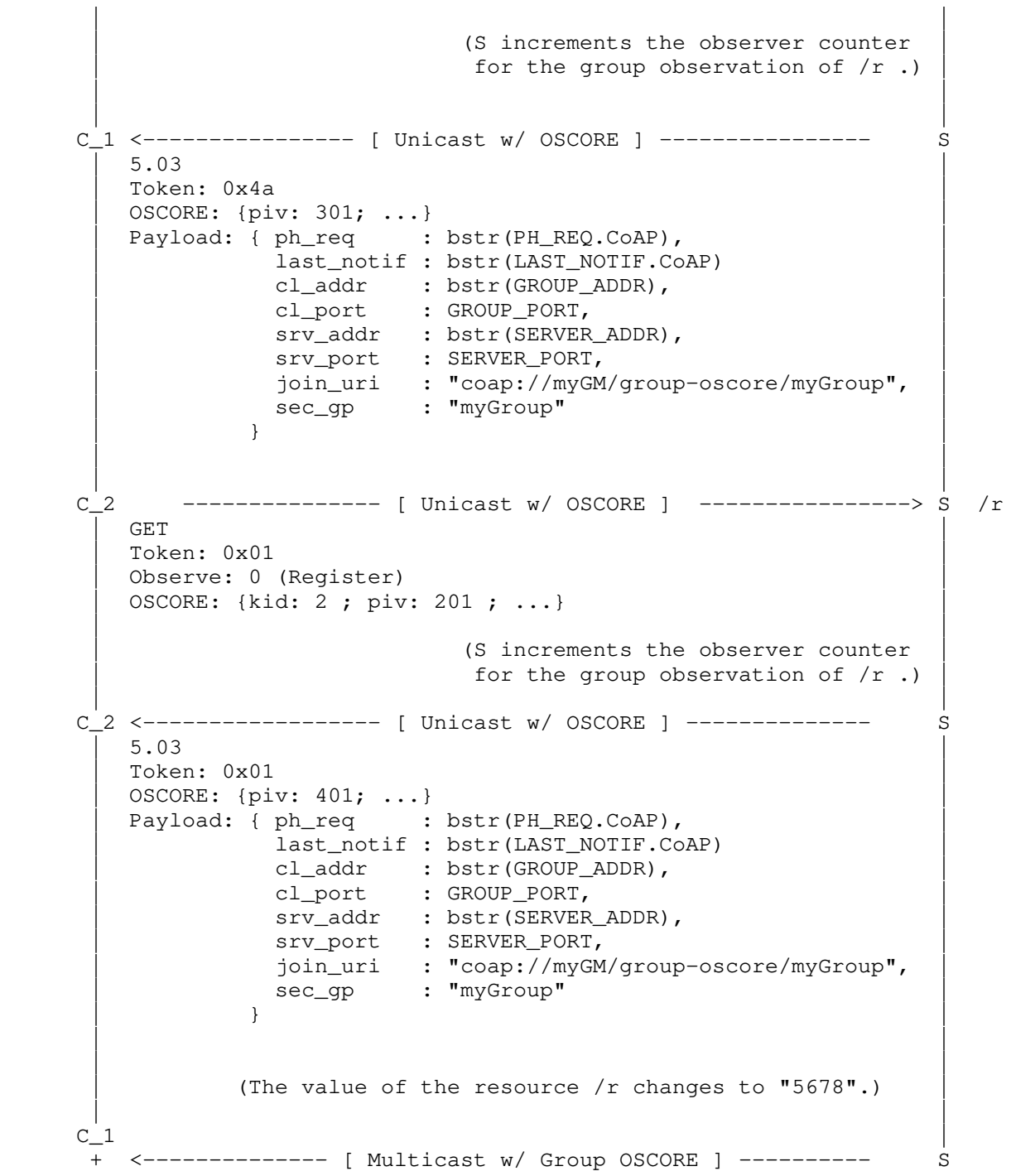
Pairwise communication over unicast are protected with OSCORE, while S protects multicast notifications with Group OSCORE. Specifically:

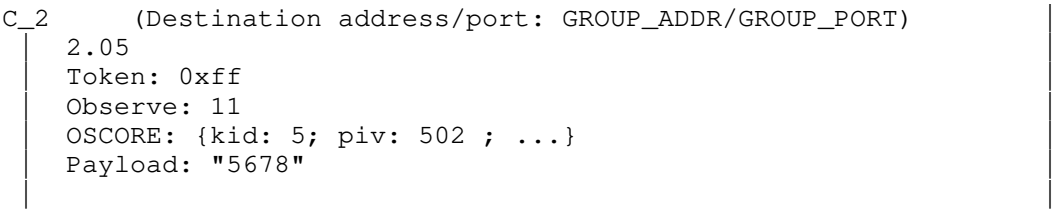
- C_1 and S have a pairwise OSCORE Security Context. In particular, C_1 has 'kid' = 1 as Sender ID, and SN_1 = 101 as Sequence Number. Also, S has 'kid' = 3 as Sender ID, and SN_3 = 301 as Sequence Number.

- C_2 and S have a pairwise OSCORE Security Context. In particular, C_2 has 'kid' = 2 as Sender ID, and SN_2 = 201 as Sequence Number. Also, S has 'kid' = 4 as Sender ID, and SN_4 = 401 as Sequence Number.

- S is a member of the OSCORE group with name "myGroup", and 'kid_context' = "feedca57ab2e" as Group ID. In the OSCORE group, S has 'kid' = 5 as Sender ID, and SN_5 = 501 as Sequence Number.




(S increments the observer counter
for the group observation of /r .)
C_1 <---------- [Unicast w/ OSCORE] ---------- S
5.03
Token: 0x4a
OSCORE: {piv: 301; ...}
Payload: { ph_req : bstr(PH_REQ.CoAP),
last_notif : bstr(LAST_NOTIF.CoAP)
cl_addr : bstr(GROUP_ADDR),
cl_port : GROUP_PORT,
srv_addr : bstr(SERVER_ADDR),
srv_port : SERVER_PORT,
join_uri : "coap://myGM/group-oscore/myGroup",
sec_gp : "myGroup"
}
C_2 ---------- [Unicast w/ OSCORE] ----------> S /r
GET
Token: 0x01
Observe: 0 (Register)
OSCORE: {kid: 2 ; piv: 201 ; ...}
(S increments the observer counter
for the group observation of /r .)
C_2 <---------- [Unicast w/ OSCORE] ---------- S
5.03
Token: 0x01
OSCORE: {piv: 401; ...}
Payload: { ph_req : bstr(PH_REQ.CoAP),
last_notif : bstr(LAST_NOTIF.CoAP)
cl_addr : bstr(GROUP_ADDR),
cl_port : GROUP_PORT,
srv_addr : bstr(SERVER_ADDR),
srv_port : SERVER_PORT,
join_uri : "coap://myGM/group-oscore/myGroup",
sec_gp : "myGroup"
}
(The value of the resource /r changes to "5678".)
C_1
+ <---------- [Multicast w/ Group OSCORE] ---------- S



The two external_aad used to encrypt and countersign the multicast notification above have 'req_kid' = 5 and 'req_iv' = 501. These are indicated in the 'kid' and 'iv' field of the OSCORE option of the phantom observation request, which is included in the 'ph_req' parameter of the unicast informative response to the two clients. Thus, the two clients can build the two same external_aad for decrypting and verifying this multicast notification and the following ones.

7. Informative Response Parameters

This specification defines a number of fields used in error messages as informative response defined in Section 2.2 of this specification.

The table below summarizes them, and specifies the CBOR key to use instead of the full descriptive name. Note that the media type application/informative-response+cbor MUST be used when these fields are transported.

Name	CBOR Key	CBOR Type	Reference
ph_req	TBD	byte string	Section 2.2
last_notif	TBD	byte string	Section 2.2
cli_addr	TBD	byte string	Section 2.2
cli_port	TBD	unsigned int	Section 2.2
srv_addr	TBD	byte string	Section 2.2
srv_port	TBD	unsigned int	Section 2.2
join_uri	TBD	text string	Section 5.1
sec_gp	TBD	text string	Section 5.1
as_uri	TBD	text string	Section 5.1
cs_alg	TBD	int / text string	Section 5.1
cs_crv	TBD	int / text string	Section 5.1
cs_kty	TBD	int / text string	Section 5.1
cs_kenc	TBD	int	Section 5.1
alg	TBD	int / text string	Section 5.1
hkdf	TBD	int / text string	Section 5.1

8. Security Considerations

The same security considerations from [RFC7252][RFC7641][I-D.ietf-core-groupcomm-bis][RFC8613][I-D.ietf-core-oscore-groupcomm] hold for this document.

If multicast notifications are protected using Group OSCORE, the original registration requests and related unicast (notification) responses MUST also be secured, including and especially the informative responses from the server. This prevents on-path active adversaries from altering the conveyed IP multicast address and serialized phantom request. Thus, it ensures secure binding between every multicast notification for a same observed resource and the phantom request that started the group observation of that resource.

To this end, clients and servers SHOULD use OSCORE or Group OSCORE, so ensuring that the secure binding above is enforced end-to-end between the server and each observing client.

9. IANA Considerations

This document has the following actions for IANA.

9.1. Media Type Registrations

This specification registers the media type 'application/informative-response+cbor' for error messages as informative response defined in Section 2.2 of this specification, when carrying parameters encoded in CBOR. This registration follows the procedures specified in [RFC6838].

- Type name: application
- Subtype name: informative-response+cbor
- Required parameters: none
- Optional parameters: none
- Encoding considerations: Must be encoded as a CBOR map containing the parameters defined in Section 2.2 of [this document].
- Security considerations: See Section 8 of [this document].
- Interoperability considerations: n/a
- Published specification: [this document]
- Applications that use this media type: The type is used by CoAP servers and clients that support error messages as informative response defined in Section 2.2 of [this document].
- Additional information:
  - Magic number(s): n/a
  - File extension(s): .informative-response
  - Macintosh file type code(s): n/a
- Person & email address to contact for further information: iesg@ietf.org [1]

- Intended usage: COMMON
- Restrictions on usage: None
- Author: Marco Tiloca marco.tiloca@ri.se [2]
- Change controller: IESG
- Provisional registration? (standards tree only): No

9.2. CoAP Content-Formats Registry

IANA is asked to add the following entry to the "CoAP Content-Formats" subregistry defined in Section 12.3 of [RFC7252], within the "Constrained RESTful Environments (CoRE) Parameters" registry.

Media Type: application/informative-response+cbor

Encoding: -

ID: TBD

Reference: [this document]

9.3. Informative Response Parameters Registry

This specification establishes the "Informative Response Parameters" IANA Registry. The Registry has been created to use the "Expert Review Required" registration procedure [RFC8126]. Expert review guidelines are provided in Section 9.5.

The columns of this Registry are:

- Name: This is a descriptive name that enables easier reference to the item. The name MUST be unique. It is not used in the encoding.
- CBOR Key: This is the value used as CBOR key of the item. These values MUST be unique. The value can be a positive integer, a negative integer, or a string.
- CBOR Type: This contains the CBOR type of the item, or a pointer to the registry that defines its type, when that depends on another item.
- Reference: This contains a pointer to the public specification for the item.

This Registry has been initially populated by the values in Section 7. The "Reference" column for all of these entries refers to sections of this document.

9.4. CoAP Option Numbers Registry

IANA is asked to enter the following option numbers to the "CoAP Option Numbers" registry defined in [RFC7252] within the "CoRE Parameters" registry.

Number	Name	Reference
TBD	Multicast-Response-Feedback-Divider	[[this document]]

9.5. Expert Review Instructions

The IANA Registries established in this document are defined as expert review. This section gives some general guidelines for what the experts should be looking for, but they are being designated as experts for a reason so they should be given substantial latitude.

Expert reviewers should take into consideration the following points:

- Point squatting should be discouraged. Reviewers are encouraged to get sufficient information for registration requests to ensure that the usage is not going to duplicate one that is already registered and that the point is likely to be used in deployments. The zones tagged as private use are intended for testing purposes and closed environments, code points in other ranges should not be assigned for testing.

- Specifications are required for the standards track range of point assignment. Specifications should exist for specification required ranges, but early assignment before a specification is available is considered to be permissible. Specifications are needed for the first-come, first-serve range if they are expected to be used outside of closed environments in an interoperable way. When specifications are not provided, the description provided needs to have sufficient information to identify what the point is being used for.

- Experts should take into account the expected usage of fields when approving point assignment. The fact that there is a range for standards track documents does not mean that a standards track document cannot have points assigned outside of that range. The length of the encoded value should be weighed against how many

code points of that length are left, the size of device it will be used on, and the number of code points left that encode to that size.

10. References

10.1. Normative References

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[COSE.Key.Types]
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10.3. URIs

[1] mailto:iesg@ietf.org

[2] mailto:marco.tiloca@ri.se

Appendix A. Pseudo-Code for Rough Counting of Clients

This appendix provides a description in pseudo-code of the two algorithms used for the rough counting of active observers, as defined in Section 2.5.1.

A.1. Client Side

```
   input:  int Q, // Value of the MRFD option
           int LEISURE_TIME, // DEFAULT_LEISURE from RFC 7252,
                             // unless overridden

   output: None


   int RAND_MIN = 0;
   int RAND_MAX = Q - 1;
   int I = randomInteger(RAND_MIN, RAND_MAX);

   if (I == 0) {
       float fraction = randomFloat(0, 1);

       Timer t = new Timer();
       t.setAndStart(fraction * LEISURE_TIME);
       while(!t.isExpired());

       Request req = new Request();
       // Initialize as NON and with maximum
       // No-Response settings, set options ...

       Option opt = new Option(OBSERVE);
       opt.set(0);
       req.setOption(opt);

       opt = new Option(MRFD);
       req.setOption(opt);

       req.send(SERVER_ADDR, SERVER_PORT);
   }
```

A.2. Server Side

```
input:  int N, // Current observer counter
        int M, // Desired number of confirmations
        int MAX_CONFIRMATION_WAIT,
        Response notification, // Multicast notification to send

output: int N // Updated observer counter


int Q = ceil(N / M);
Option opt = new Option(MRFD);
opt.set(Q);

notification.setOption(opt);
<Finalize the notification message>
notification.send(GROUP_ADDR, GROUP_PORT);

Timer t = new Timer();
t.setAndStart(MAX_CONFIRMATION_WAIT); // Time t1
while(!t.isExpired());

// Time t2

int R = <number of requests to the resource between t1 and t2,
         with the MRFD option>;
int X = <number of requests to the resource between t1 and t2,
         without the MRFD option>;

int N = (R * Q) + X;
return N;
```

Appendix B. Different Sources for Group Observation Data

While the clients usually receive the phantom request and other information related to the group observation through an Informative Response, the same data can be made available through different services, such as the following ones.

B.1. PubSub

In a pubsub case ([I-D.ietf-core-coap-pubsub]), a group observation can be discovered, along with topic metadata. For instance, a discovery step can make the following metadata available.

This examples assumes a CoRAL namespace that contains properties analogous to those in the content-format application/informative-response+cbor.

Request:

```
GET </ps/topics?rt=oic.r.temperature>
Accept: CoRAL
```

Response:

```
2.05 Content
Content-Format: CoRAL

rdf:type <http://example.org/pubsub/topic-list>
topic </ps/topics/1234> {
    ph_req h"120100006464b431323334"
    last_notif h"120100006464b431324321"
    cli_addr h"ff35003020010db8..1234"
    cli_port 5683
    srv_addr h"20010db80100..0001"
    srv_port 5683
}
```

With this information from the topic discovery step, the client can already set up its multicast address and start receiving multicast notifications.

In heavily asymmetric networks like municipal notification services, discovery and notifications do not necessarily need to use the same network link. For example, a departure monitor could use its (costly and usually-off) cellular uplink to discover the topics it needs to update its display to, and then listen on a LoRA-WAN interface for receiving the actual multicast notifications.

B.2. Sender Introspection

For network debugging purposes, it can be useful to query a server that sends multicast responses as matching a phantom request.

Such an interface is left for other documents to specify on demand, but could look like this as relying on the already known token value of multicast notifications associated to a phantom request:

Request:

```
GET </.well-known/core/mc-sender?token=6464>
```

Response:

```
2.05 Content
Content-Format: application/informative-response+cbor

{
    'ph_req': h"120100006464b431323334"
    'last_notif' : h"120100006464b431324321"
    'cli_addr': h"ff35003020010db8..1234"
    'cli_port': 5683
    'srv_addr': h"20010db80100..0001"
    'srv_port': 5683
}
```

For example, a network sniffer could offer sending such a request when unknown multicast notifications are seen on a network. Consequently, it can associate those notifications with a URI, or decrypt them, if member of the correct OSCORE group.

Acknowledgments

The authors sincerely thank Carsten Bormann, Klaus Hartke, Jaime Jimenez, John Mattsson, Ludwig Seitz, Jim Schaad and Goeran Selander for their comments and feedback.

The work on this document has been partly supported by VINNOVA and the Celtic-Next project CRITISEC.

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