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Diameter Overload Indication Conveyance

Abstract

This specification defines a base solution for Diameter overload control, referred to as Diameter Overload Indication Conveyance (DOIC).

Status of This Memo

This is an Internet Standards Track document.

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1. Introduction

This specification defines a base solution for Diameter overload control, referred to as Diameter Overload Indication Conveyance (DOIC), based on the requirements identified in [RFC7068].

This specification addresses Diameter overload control between Diameter nodes that support the DOIC solution. The solution, which is designed to apply to existing and future Diameter applications, requires no changes to the Diameter base protocol [RFC6733] and is deployable in environments where some Diameter nodes do not implement the Diameter overload control solution defined in this specification.

A new application specification can incorporate the overload control mechanism specified in this document by making it mandatory to implement for the application and referencing this specification normatively. It is the responsibility of the Diameter application designers to define how overload control mechanisms work on that application.

Note that the overload control solution defined in this specification does not address all the requirements listed in [RFC7068]. A number of features related to overload control are left for future specifications. See Appendix A for a list of extensions that are currently being considered.

2. Terminology and Abbreviations

Abatement

Reaction to receipt of an overload report resulting in a reduction in traffic sent to the reporting node. Abatement actions include diversion and throttling.

Abatement Algorithm

An extensible method requested by reporting nodes and used by reacting nodes to reduce the amount of traffic sent during an occurrence of overload control.

Diversion

An overload abatement treatment where the reacting node selects alternate destinations or paths for requests.

Host-Routed Requests

Requests that a reacting node knows will be served by a particular host, either due to the presence of a Destination-Host Attribute Value Pair (AVP) or by some other local knowledge on the part of the reacting node.

Overload Control State (OCS)

Internal state maintained by a reporting or reacting node describing occurrences of overload control.

Overload Report (OLR)

Overload control information for a particular overload occurrence sent by a reporting node.

Reacting Node

A Diameter node that acts upon an overload report.

Realm-Routed Requests

Requests sent by a reacting node where the reacting node does not know to which host the request will be routed.

Reporting Node

A Diameter node that generates an overload report. (This may or may not be the overloaded node.)

Throttling

An abatement treatment that limits the number of requests sent by the reacting node. Throttling can include a Diameter Client choosing to not send requests, or a Diameter Agent or Server rejecting requests with appropriate error responses. In both cases, the result of the throttling is a permanent rejection of the transaction.

3. Conventions Used in This Document

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].

The interpretation from RFC 2119 [RFC2119] does not apply for the above listed words when they are not used in all caps.

4. Solution Overview

The Diameter Overload Information Conveyance (DOIC) solution allows Diameter nodes to request that other Diameter nodes perform overload abatement actions, that is, actions to reduce the load offered to the overloaded node or realm.

A Diameter node that supports DOIC is known as a "DOIC node". Any Diameter node can act as a DOIC node, including Diameter Clients, Diameter Servers, and Diameter Agents. DOIC nodes are further divided into "Reporting Nodes" and "Reacting Nodes." A reporting node requests overload abatement by sending Overload Reports (OLRs).

A reacting node acts upon OLRs and performs whatever actions are needed to fulfill the abatement requests included in the OLRs. A reporting node may report overload on its own behalf or on behalf of other nodes. Likewise, a reacting node may perform overload abatement on its own behalf or on behalf of other nodes.

A Diameter node's role as a DOIC node is independent of its Diameter role. For example, Diameter Agents may act as DOIC nodes, even though they are not endpoints in the Diameter sense. Since Diameter enables bidirectional applications, where Diameter Servers can send requests towards Diameter Clients, a given Diameter node can simultaneously act as both a reporting node and a reacting node.

Likewise, a Diameter Agent may act as a reacting node from the perspective of upstream nodes, and a reporting node from the perspective of downstream nodes.

DOIC nodes do not generate new messages to carry DOIC-related information. Rather, they "piggyback" DOIC information over existing Diameter messages by inserting new AVPs into existing Diameter requests and responses. Nodes indicate support for DOIC, and any needed DOIC parameters, by inserting an OC-Supported-Features AVP (Section 7.1) into existing requests and responses. Reporting nodes send OLRs by inserting OC-OLR AVPs (Section 7.3).

A given OLR applies to the Diameter realm and application of the Diameter message that carries it. If a reporting node supports more than one realm and/or application, it reports independently for each combination of realm and application. Similarly, the OC-Supported-Features AVP applies to the realm and application of the enclosing message. This implies that a node may support DOIC for one application and/or realm, but not another, and may indicate different DOIC parameters for each application and realm for which it supports DOIC.

Reacting nodes perform overload abatement according to an agreed-upon abatement algorithm. An abatement algorithm defines the meaning of some of the parameters of an OLR and the procedures required for overload abatement. An overload abatement algorithm separates Diameter requests into two sets. The first set contains the requests that are to undergo overload abatement treatment of either throttling or diversion. The second set contains the requests that are to be given normal routing treatment. This document specifies a single "must-support" algorithm, namely, the "loss" algorithm (Section 6). Future specifications may introduce new algorithms.

Overload conditions may vary in scope. For example, a single Diameter node may be overloaded, in which case, reacting nodes may attempt to send requests to other destinations. On the other hand, an entire Diameter realm may be overloaded, in which case, such attempts would do harm. DOIC OLRs have a concept of "report type" (Section 7.6), where the type defines such behaviors. Report types are extensible. This document defines report types for overload of a specific host and for overload of an entire realm.

DOIC works through non-supporting Diameter Agents that properly pass unknown AVPs unchanged.

4.1. Piggybacking

There is no new Diameter application defined to carry overload-related AVPs. The overload control AVPs defined in this specification have been designed to be piggybacked on top of existing

application messages. This is made possible by adding the optional overload control AVPs OC-OLR and OC-Supported-Features into existing commands.

Reacting nodes indicate support for DOIC by including the OC-Supported-Features AVP in all request messages originated or relayed by the reacting node.

Reporting nodes indicate support for DOIC by including the OC-Supported-Features AVP in all answer messages that are originated or relayed by the reporting node and that are in response to a request that contained the OC-Supported-Features AVP. Reporting nodes may include overload reports using the OC-OLR AVP in answer messages.

Note that the overload control solution does not have fixed server and client roles. The DOIC node role is determined based on the message type: whether the message is a request (i.e., sent by a "reacting node") or an answer (i.e., sent by a "reporting node"). Therefore, in a typical client-server deployment, the Diameter Client may report its overload condition to the Diameter Server for any Diameter-Server-initiated message exchange. An example of such is the Diameter Server requesting a re-authentication from a Diameter Client.

4.2. DOIC Capability Announcement

The DOIC solution supports the ability for Diameter nodes to determine if other nodes in the path of a request support the solution. This capability is referred to as DOIC Capability Announcement (DCA) and is separate from the Diameter Capability Exchange.

The DCA mechanism uses the OC-Supported-Features AVPs to indicate the Diameter overload features supported.

The first node in the path of a Diameter request that supports the DOIC solution inserts the OC-Supported-Features AVP in the request message.

The individual features supported by the DOIC nodes are indicated in the OC-Feature-Vector AVP. Any semantics associated with the features will be defined in extension specifications that introduce the features.

Note: As discussed elsewhere in the document, agents in the path of the request can modify the OC-Supported-Features AVP.

Note: The DOIC solution must support deployments where Diameter Clients and/or Diameter Servers do not support the DOIC solution. In this scenario, Diameter Agents that support the DOIC solution may handle overload abatement for the non-supporting Diameter nodes. In this case, the DOIC agent will insert the OC-Supported-Features AVP in requests that do not already contain one, telling the reporting node that there is a DOIC node that will handle overload abatement. For transactions where there was an OC-Supported-Features AVP in the request, the agent will insert the OC-Supported-Features AVP in answers, telling the reacting node that there is a reporting node.

The OC-Feature-Vector AVP will always contain an indication of support for the loss overload abatement algorithm defined in this specification (see Section 6). This ensures that a reporting node always supports at least one of the advertised abatement algorithms received in a request messages.

The reporting node inserts the OC-Supported-Features AVP in all answer messages to requests that contained the OC-Supported-Features AVP. The contents of the reporting node's OC-Supported-Features AVP indicate the set of Diameter overload features supported by the reporting node. This specification defines one exception -- the reporting node only includes an indication of support for one overload abatement algorithm, independent of the number of overload abatement algorithms actually supported by the reacting node. The overload abatement algorithm indicated is the algorithm that the reporting node intends to use should it enter an overload condition. Reacting nodes can use the indicated overload abatement algorithm to prepare for possible overload reports and must use the indicated overload abatement algorithm if traffic reduction is actually requested.

Note that the loss algorithm defined in this document is a stateless abatement algorithm. As a result, it does not require any actions by reacting nodes prior to the receipt of an overload report. Stateful abatement algorithms that base the abatement logic on a history of request messages sent might require reacting nodes to maintain state in advance of receiving an overload report to ensure that the overload reports can be properly handled.

While it should only be done in exceptional circumstances and not during an active occurrence of overload, a reacting node that wishes to transition to a different abatement algorithm can stop advertising support for the algorithm indicated by the reporting node, as long as support for the loss algorithm is always advertised.

The DCA mechanism must also allow the scenario where the set of features supported by the sender of a request and by agents in the path of a request differ. In this case, the agent can update the OC-Supported-Features AVP to reflect the mixture of the two sets of supported features.

Note: The logic to determine if the content of the OC-Supported-Features AVP should be changed is out of scope for this document, as is the logic to determine the content of a modified OC-Supported-Features AVP. These are left to implementation decisions. Care must be taken not to introduce interoperability issues for downstream or upstream DOIC nodes. As such, the agent must act as a fully compliant reporting node to the downstream reacting node and as a fully compliant reacting node to the upstream reporting node.

4.3. DOIC Overload Condition Reporting

As with DOIC capability announcement, overload condition reporting uses new AVPs (Section 7.3) to indicate an overload condition.

The OC-OLR AVP is referred to as an overload report. The OC-OLR AVP includes the type of report, a sequence number, the length of time that the report is valid, and AVPs specific to the abatement algorithm.

Two types of overload reports are defined in this document: host reports and realm reports.

A report of type "HOST_REPORT" is sent to indicate the overload of a specific host, identified by the Origin-Host AVP of the message containing the OLR, for the Application-ID indicated in the transaction. When receiving an OLR of type "HOST_REPORT", a reacting node applies overload abatement treatment to the host-routed requests identified by the overload abatement algorithm (as defined in Section 2) sent for this application to the overloaded host.

A report of type "REALM_REPORT" is sent to indicate the overload of a realm for the Application-ID indicated in the transaction. The overloaded realm is identified by the Destination-Realm AVP of the message containing the OLR. When receiving an OLR of type "REALM_REPORT", a reacting node applies overload abatement treatment to realm-routed requests identified by the overload abatement algorithm (as defined in Section 2) sent for this application to the overloaded realm.

This document assumes that there is a single source for realm reports for a given realm, or that if multiple nodes can send realm reports, that each such node has full knowledge of the overload state of the entire realm. A reacting node cannot distinguish between receiving realm reports from a single node or from multiple nodes.

Note: Known issues exist if there are multiple sources for overload reports that apply to the same Diameter entity. Reacting nodes have no way of determining the source and, as such, will treat them as coming from a single source. Variance in sequence numbers between the two sources can then cause incorrect overload abatement treatment to be applied for indeterminate periods of time.

Reporting nodes are responsible for determining the need for a reduction of traffic. The method for making this determination is implementation specific and depends on the type of overload report being generated. A host report might be generated by tracking use of resources required by the host to handle transactions for the Diameter application. A realm report generally impacts the traffic sent to multiple hosts and, as such, requires tracking the capacity of all servers able to handle realm-routed requests for the application and realm.

Once a reporting node determines the need for a reduction in traffic, it uses the DOIC-defined AVPs to report on the condition. These AVPs are included in answer messages sent or relayed by the reporting node. The reporting node indicates the overload abatement algorithm that is to be used to handle the traffic reduction in the OC-Supported-Features AVP. The OC-OLR AVP is used to communicate information about the requested reduction.

Reacting nodes, upon receipt of an overload report, apply the overload abatement algorithm to traffic impacted by the overload report. The method used to determine the requests that are to receive overload abatement treatment is dependent on the abatement algorithm. The loss abatement algorithm is defined in this document (Section 6). Other abatement algorithms can be defined in extensions to the DOIC solution.

Two types of overload abatement treatment are defined, diversion and throttling. Reacting nodes are responsible for determining which treatment is appropriate for individual requests.

As the conditions that lead to the generation of the overload report change, the reporting node can send new overload reports requesting greater reduction if the condition gets worse or less reduction if the condition improves. The reporting node sends an overload report

with a duration of zero to indicate that the overload condition has ended and abatement is no longer needed.

The reacting node also determines when the overload report expires based on the OC-Validity-Duration AVP in the overload report and stops applying the abatement algorithm when the report expires.

Note that erroneous overload reports can be used for DoS attacks. This includes the ability to indicate that a significant reduction in traffic, up to and including a request for no traffic, should be sent to a reporting node. As such, care should be taken to verify the sender of overload reports.

4.4. DOIC Extensibility

The DOIC solution is designed to be extensible. This extensibility is based on existing Diameter-based extensibility mechanisms, along with the DOIC capability announcement mechanism.

There are multiple categories of extensions that are expected. This includes the definition of new overload abatement algorithms, the definition of new report types, and the definition of new scopes of messages impacted by an overload report.

A DOIC node communicates supported features by including them in the OC-Feature-Vector AVP, as a sub-AVP of OC-Supported-Features. Any non-backwards-compatible DOIC extensions define new values for the OC-Feature-Vector AVP. DOIC extensions also have the ability to add new AVPs to the OC-Supported-Features AVP, if additional information about the new feature is required.

Overload reports can also be extended by adding new sub-AVPs to the OC-OLR AVP, allowing reporting nodes to communicate additional information about handling an overload condition.

If necessary, new extensions can also define new AVPs that are not part of the OC-Supported-Features and OC-OLR group AVPs. It is, however, recommended that DOIC extensions use the OC-Supported-Features AVP and OC-OLR AVP to carry all DOIC-related AVPs.

4.5. Simplified Example Architecture

Figure 1 illustrates the simplified architecture for Diameter overload information conveyance.

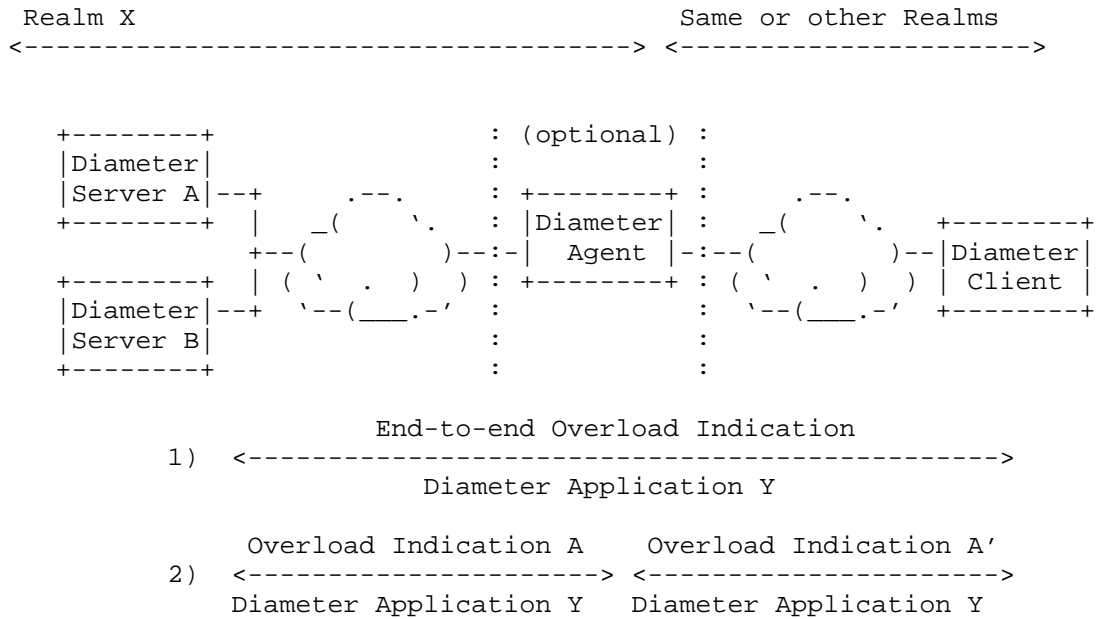


Figure 1: Simplified Architecture Choices for Overload Indication Delivery

In Figure 1, the Diameter overload indication can be conveyed (1) end-to-end between servers and clients or (2) between servers and the Diameter Agent inside the realm and then between the Diameter Agent and the clients.

5. Solution Procedures

This section outlines the normative behavior for the DOIC solution.

5.1. Capability Announcement

This section defines DOIC Capability Announcement (DCA) behavior.

Note: This specification assumes that changes in DOIC node capabilities are relatively rare events that occur as a result of administrative action. Reacting nodes ought to minimize changes that force the reporting node to change the features being used, especially during active overload conditions. But even if

reacting nodes avoid such changes, reporting nodes still have to be prepared for them to occur. For example, differing capabilities between multiple reacting nodes may still force a reporting node to select different features on a per-transaction basis.

5.1.1. Reacting Node Behavior

A reacting node MUST include the OC-Supported-Features AVP in all requests. It MAY include the OC-Feature-Vector AVP, as a sub-AVP of OC-Supported-Features. If it does so, it MUST indicate support for the "loss" algorithm. If the reacting node is configured to support features (including other algorithms) in addition to the loss algorithm, it MUST indicate such support in an OC-Feature-Vector AVP.

An OC-Supported-Features AVP in answer messages indicates there is a reporting node for the transaction. The reacting node MAY take action, for example, creating state for some stateful abatement algorithm, based on the features indicated in the OC-Feature-Vector AVP.

Note: The loss abatement algorithm does not require stateful behavior when there is no active overload report.

Reacting nodes need to be prepared for the reporting node to change selected algorithms. This can happen at any time, including when the reporting node has sent an active overload report. The reacting node can minimize the potential for changes by modifying the advertised abatement algorithms sent to an overloaded reporting node to the currently selected algorithm and loss (or just loss if it is the currently selected algorithm). This has the effect of limiting the potential change in abatement algorithm from the currently selected algorithm to loss, avoiding changes to more complex abatement algorithms that require state to operate properly.

5.1.2. Reporting Node Behavior

Upon receipt of a request message, a reporting node determines if there is a reacting node for the transaction based on the presence of the OC-Supported-Features AVP in the request message.

If the request message contains an OC-Supported-Features AVP, then a reporting node MUST include the OC-Supported-Features AVP in the answer message for that transaction.

Note: Capability announcement is done on a per-transaction basis. The reporting node cannot assume that the capabilities announced by a reacting node will be the same between transactions.

A reporting node MUST NOT include the OC-Supported-Features AVP, OC-OLR AVP, or any other overload control AVPs defined in extension documents in response messages for transactions where the request message does not include the OC-Supported-Features AVP. Lack of the OC-Supported-Features AVP in the request message indicates that there is no reacting node for the transaction.

A reporting node knows what overload control functionality is supported by the reacting node based on the content or absence of the OC-Feature-Vector AVP within the OC-Supported-Features AVP in the request message.

A reporting node MUST select a single abatement algorithm in the OC-Feature-Vector AVP. The abatement algorithm selected MUST indicate the abatement algorithm the reporting node wants the reacting node to use when the reporting node enters an overload condition.

The abatement algorithm selected MUST be from the set of abatement algorithms contained in the request message's OC-Feature-Vector AVP.

A reporting node that selects the loss algorithm may do so by including the OC-Feature-Vector AVP with an explicit indication of the loss algorithm, or it MAY omit the OC-Feature-Vector AVP. If it selects a different algorithm, it MUST include the OC-Feature-Vector AVP with an explicit indication of the selected algorithm.

The reporting node SHOULD indicate support for other DOIC features defined in extension documents that it supports and that apply to the transaction. It does so using the OC-Feature-Vector AVP.

Note: Not all DOIC features will apply to all Diameter applications or deployment scenarios. The features included in the OC-Feature-Vector AVP are based on local policy of the reporting node.

5.1.3. Agent Behavior

Diameter Agents that support DOIC can ensure that all messages relayed by the agent contain the OC-Supported-Features AVP.

A Diameter Agent MAY take on reacting node behavior for Diameter endpoints that do not support the DOIC solution. A Diameter Agent detects that a Diameter endpoint does not support DOIC reacting node behavior when there is no OC-Supported-Features AVP in a request message.

For a Diameter Agent to be a reacting node for a non-supporting Diameter endpoint, the Diameter Agent MUST include the OC-Supported-Features AVP in request messages it relays that do not contain the OC-Supported-Features AVP.

A Diameter Agent MAY take on reporting node behavior for Diameter endpoints that do not support the DOIC solution. The Diameter Agent MUST have visibility to all traffic destined for the non-supporting host in order to become the reporting node for the Diameter endpoint. A Diameter Agent detects that a Diameter endpoint does not support DOIC reporting node behavior when there is no OC-Supported-Features AVP in an answer message for a transaction that contained the OC-Supported-Features AVP in the request message.

If a request already has the OC-Supported-Features AVP, a Diameter Agent MAY modify it to reflect the features appropriate for the transaction. Otherwise, the agent relays the OC-Supported-Features AVP without change.

Example: If the agent supports a superset of the features reported by the reacting node, then the agent might choose, based on local policy, to advertise that superset of features to the reporting node.

If the Diameter Agent changes the OC-Supported-Features AVP in a request message, then it is likely it will also need to modify the OC-Supported-Features AVP in the answer message for the transaction. A Diameter Agent MAY modify the OC-Supported-Features AVP carried in answer messages.

When making changes to the OC-Supported-Features or OC-OLR AVPs, the Diameter Agent needs to ensure consistency in its behavior with both upstream and downstream DOIC nodes.

5.2. Overload Report Processing

5.2.1. Overload Control State

Both reacting and reporting nodes maintain Overload Control State (OCS) for active overload conditions. The following sections define behavior associated with that OCS.

The contents of the OCS in the reporting node and in the reacting node represent logical constructs. The actual internal physical structure of the state included in the OCS is an implementation decision.

5.2.1.1. Overload Control State for Reacting Nodes

A reacting node maintains the following OCS per supported Diameter application:

- o a host-type OCS entry for each Destination-Host to which it sends host-type requests and
- o a realm-type OCS entry for each Destination-Realm to which it sends realm-type requests.

A host-type OCS entry is identified by the pair of Application-ID and the node's DiameterIdentity.

A realm-type OCS entry is identified by the pair of Application-ID and realm.

The host-type and realm-type OCS entries include the following information (the actual information stored is an implementation decision):

- o Sequence number (as received in OC-OLR; see Section 7.3)
- o Time of expiry (derived from OC-Validity-Duration AVP received in the OC-OLR AVP and time of reception of the message carrying OC-OLR AVP)
- o Selected abatement algorithm (as received in the OC-Supported-Features AVP)
- o Input data that is abatement algorithm specific (as received in the OC-OLR AVP -- for example, OC-Reduction-Percentage for the loss abatement algorithm)

5.2.1.2. Overload Control State for Reporting Nodes

A reporting node maintains OCS entries per supported Diameter application, per supported (and eventually selected) abatement algorithm, and per report type.

An OCS entry is identified by the tuple of Application-ID, report type, and abatement algorithm, and it includes the following information (the actual information stored is an implementation decision):

- o Sequence number
- o Validity duration

- o Expiration time
- o Input data that is algorithm specific (for example, the reduction percentage for the loss abatement algorithm)

5.2.1.3. Reacting Node's Maintenance of Overload Control State

When a reacting node receives an OC-OLR AVP, it MUST determine if it is for an existing or new overload condition.

Note: For the remainder of this section, the term "OLR" refers to the combination of the contents of the received OC-OLR AVP and the abatement algorithm indicated in the received OC-Supported-Features AVP.

When receiving an answer message with multiple OLRs of different supported report types, a reacting node MUST process each received OLR.

The OLR is for an existing overload condition if a reacting node has an OCS that matches the received OLR.

For a host report, this means it matches the Application-ID and the host's DiameterIdentity in an existing host OCS entry.

For a realm report, this means it matches the Application-ID and the realm in an existing realm OCS entry.

If the OLR is for an existing overload condition, then a reacting node MUST determine if the OLR is a retransmission or an update to the existing OLR.

If the sequence number for the received OLR is greater than the sequence number stored in the matching OCS entry, then a reacting node MUST update the matching OCS entry.

If the sequence number for the received OLR is less than or equal to the sequence number in the matching OCS entry, then a reacting node MUST silently ignore the received OLR. The matching OCS MUST NOT be updated in this case.

If the reacting node determines that the sequence number has rolled over, then the reacting node MUST update the matching OCS entry. This can be determined by recognizing that the number has changed from a value within 1% of the maximum value in the OC-Sequence-Number AVP to a value within 1% of the minimum value in the OC-Sequence-Number AVP.

If the received OLR is for a new overload condition, then a reacting node MUST generate a new OCS entry for the overload condition.

For a host report, this means a reacting node creates an OCS entry with the Application-ID in the received message and DiameterIdentity of the Origin-Host in the received message.

Note: This solution assumes that the Origin-Host AVP in the answer message included by the reporting node is not changed along the path to the reacting node.

For a realm report, this means a reacting node creates an OCS entry with the Application-ID in the received message and realm of the Origin-Realm in the received message.

If the received OLR contains a validity duration of zero ("0"), then a reacting node MUST update the OCS entry as being expired.

Note: It is not necessarily appropriate to delete the OCS entry, as the recommended behavior is that the reacting node slowly returns to full traffic when ending an overload abatement period.

The reacting node does not delete an OCS when receiving an answer message that does not contain an OC-OLR AVP (i.e., absence of OLR means "no change").

5.2.1.4. Reporting Node's Maintenance of Overload Control State

A reporting node SHOULD create a new OCS entry when entering an overload condition.

Note: If a reporting node knows through absence of the OC-Supported-Features AVP in received messages that there are no reacting nodes supporting DOIC, then the reporting node can choose to not create OCS entries.

When generating a new OCS entry, the sequence number SHOULD be set to zero ("0").

When generating sequence numbers for new overload conditions, the new sequence number MUST be greater than any sequence number in an active (unexpired) overload report for the same application and report type previously sent by the reporting node. This property MUST hold over a reboot of the reporting node.

Note: One way of addressing this over a reboot of a reporting node is to use a timestamp for the first overload condition that occurs after the report and to start using sequences beginning with zero for subsequent overload conditions.

A reporting node MUST update an OCS entry when it needs to adjust the validity duration of the overload condition at reacting nodes.

Example: If a reporting node wishes to instruct reacting nodes to continue overload abatement for a longer period of time than originally communicated. This also applies if the reporting node wishes to shorten the period of time that overload abatement is to continue.

A reporting node MUST update an OCS entry when it wishes to adjust any parameters specific to the abatement algorithm, including, for example, the reduction percentage used for the loss abatement algorithm.

Example: If a reporting node wishes to change the reduction percentage either higher (if the overload condition has worsened) or lower (if the overload condition has improved), then the reporting node would update the appropriate OCS entry.

A reporting node MUST increment the sequence number associated with the OCS entry anytime the contents of the OCS entry are changed. This will result in a new sequence number being sent to reacting nodes, instructing them to process the OC-OLR AVP.

A reporting node SHOULD update an OCS entry with a validity duration of zero ("0") when the overload condition ends.

Note: If a reporting node knows that the OCS entries in the reacting nodes are near expiration, then the reporting node might decide not to send an OLR with a validity duration of zero.

A reporting node MUST keep an OCS entry with a validity duration of zero ("0") for a period of time long enough to ensure that any unexpired reacting node's OCS entry created as a result of the overload condition in the reporting node is deleted.

5.2.2. Reacting Node Behavior

When a reacting node sends a request, it MUST determine if that request matches an active OCS.

If the request matches an active OCS, then the reacting node **MUST** use the overload abatement algorithm indicated in the OCS to determine if the request is to receive overload abatement treatment.

For the loss abatement algorithm defined in this specification, see Section 6 for the overload abatement algorithm logic applied.

If the overload abatement algorithm selects the request for overload abatement treatment, then the reacting node **MUST** apply overload abatement treatment on the request. The abatement treatment applied depends on the context of the request.

If diversion abatement treatment is possible (i.e., a different path for the request can be selected where the overloaded node is not part of the different path), then the reacting node **SHOULD** apply diversion abatement treatment to the request. The reacting node **MUST** apply throttling abatement treatment to requests identified for abatement treatment when diversion treatment is not possible or was not applied.

Note: This only addresses the case where there are two defined abatement treatments, diversion and throttling. Any extension that defines a new abatement treatment must also define its interaction with existing treatments.

If the overload abatement treatment results in throttling of the request and if the reacting node is an agent, then the agent **MUST** send an appropriate error as defined in Section 8.

Diameter endpoints that throttle requests need to do so according to the rules of the client application. Those rules will vary by application and are beyond the scope of this document.

In the case that the OCS entry indicated no traffic was to be sent to the overloaded entity and the validity duration expires, then overload abatement associated with the overload report **MUST** be ended in a controlled fashion.

5.2.3. Reporting Node Behavior

If there is an active OCS entry, then a reporting node **SHOULD** include the OC-OLR AVP in all answers to requests that contain the OC-Supported-Features AVP and that match the active OCS entry.

Note: A request matches 1) if the Application-ID in the request matches the Application-ID in any active OCS entry and 2) if the report type in the OCS entry matches a report type supported by the reporting node as indicated in the OC-Supported-Features AVP.

The contents of the OC-OLR AVP depend on the selected algorithm.

A reporting node MAY choose to not resend an overload report to a reacting node if it can guarantee that this overload report is already active in the reacting node.

Note: In some cases (e.g., when there are one or more agents in the path between reporting and reacting nodes, or when overload reports are discarded by reacting nodes), a reporting node may not be able to guarantee that the reacting node has received the report.

A reporting node MUST NOT send overload reports of a type that has not been advertised as supported by the reacting node.

Note: A reacting node implicitly advertises support for the host and realm report types by including the OC-Supported-Features AVP in the request. Support for other report types will be explicitly indicated by new feature bits in the OC-Feature-Vector AVP.

A reporting node SHOULD explicitly indicate the end of an overload occurrence by sending a new OLR with OC-Validity-Duration set to a value of zero ("0"). The reporting node SHOULD ensure that all reacting nodes receive the updated overload report.

A reporting node MAY rely on the OC-Validity-Duration AVP values for the implicit cleanup of overload control state on the reacting node.

Note: All OLRs sent have an expiration time calculated by adding the validity duration contained in the OLR to the time the message was sent. Transit time for the OLR can be safely ignored. The reporting node can ensure that all reacting nodes have received the OLR by continuing to send it in answer messages until the expiration time for all OLRs sent for that overload condition have expired.

When a reporting node sends an OLR, it effectively delegates any necessary throttling to downstream nodes. If the reporting node also locally throttles the same set of messages, the overall number of throttled requests may be higher than intended. Therefore, before applying local message throttling, a reporting node needs to check if these messages match existing OCS entries, indicating that these messages have survived throttling applied by downstream nodes that have received the related OLR.

However, even if the set of messages match existing OCS entries, the reporting node can still apply other abatement methods such as diversion. The reporting node might also need to throttle requests

for reasons other than overload. For example, an agent or server might have a configured rate limit for each client and might throttle requests that exceed that limit, even if such requests had already been candidates for throttling by downstream nodes. The reporting node also has the option to send new OLRs requesting greater reductions in traffic, reducing the need for local throttling.

A reporting node SHOULD decrease requested overload abatement treatment in a controlled fashion to avoid oscillations in traffic.

Example: A reporting node might wait some period of time after overload ends before terminating the OLR, or it might send a series of OLRs indicating progressively less overload severity.

5.3. Protocol Extensibility

The DOIC solution can be extended. Types of potential extensions include new traffic abatement algorithms, new report types, or other new functionality.

When defining a new extension that requires new normative behavior, the specification must define a new feature for the OC-Feature-Vector AVP. This feature bit is used to communicate support for the new feature.

The extension may define new AVPs for use in the DOIC Capability Announcement and for use in DOIC overload reporting. These new AVPs SHOULD be defined to be extensions to the OC-Supported-Features or OC-OLR AVPs defined in this document.

The Grouped AVP extension mechanisms defined in [RFC6733] apply. This allows, for example, defining a new feature that is mandatory to be understood even when piggybacked on an existing application.

When defining new report type values, the corresponding specification must define the semantics of the new report types and how they affect the OC-OLR AVP handling.

The OC-Supported-Feature and OC-OLR AVPs can be expanded with optional sub-AVPs only if a legacy DOIC implementation can safely ignore them without breaking backward compatibility for the given OC-Report-Type AVP value. Any new sub-AVPs must not require that the M-bit be set.

Documents that introduce new report types must describe any limitations on their use across non-supporting agents.

As with any Diameter specification, RFC 6733 requires all new AVPs to be registered with IANA. See Section 9 for the required procedures. New features (feature bits in the OC-Feature-Vector AVP) and report types (in the OC-Report-Type AVP) MUST be registered with IANA.

6. Loss Algorithm

This section documents the Diameter overload loss abatement algorithm.

6.1. Overview

The DOIC specification supports the ability for multiple overload abatement algorithms to be specified. The abatement algorithm used for any instance of overload is determined by the DOIC Capability Announcement process documented in Section 5.1.

The loss algorithm described in this section is the default algorithm that must be supported by all Diameter nodes that support DOIC.

The loss algorithm is designed to be a straightforward and stateless overload abatement algorithm. It is used by reporting nodes to request a percentage reduction in the amount of traffic sent. The traffic impacted by the requested reduction depends on the type of overload report.

Reporting nodes request the stateless reduction of the number of requests by an indicated percentage. This percentage reduction is in comparison to the number of messages the node otherwise would send, regardless of how many requests the node might have sent in the past.

From a conceptual level, the logic at the reacting node could be outlined as follows.

1. An overload report is received, and the associated OCS is either saved or updated (if required) by the reacting node.
2. A new Diameter request is generated by the application running on the reacting node.
3. The reacting node determines that an active overload report applies to the request, as indicated by the corresponding OCS entry.
4. The reacting node determines if overload abatement treatment should be applied to the request. One approach that could be taken for each request is to select a uniformly selected random number between 1 and 100. If the random number is less than or

equal to the indicated reduction percentage, then the request is given abatement treatment; otherwise, the request is given normal routing treatment.

6.2. Reporting Node Behavior

The method a reporting node uses to determine the amount of traffic reduction required to address an overload condition is an implementation decision.

When a reporting node that has selected the loss abatement algorithm determines the need to request a reduction in traffic, it includes an OC-OLR AVP in answer messages as described in Section 5.2.3.

When sending the OC-OLR AVP, the reporting node MUST indicate a percentage reduction in the OC-Reduction-Percentage AVP.

The reporting node MAY change the reduction percentage in subsequent overload reports. When doing so, the reporting node must conform to overload report handling specified in Section 5.2.3.

6.3. Reacting Node Behavior

The method a reacting node uses to determine which request messages are given abatement treatment is an implementation decision.

When receiving an OC-OLR in an answer message where the algorithm indicated in the OC-Supported-Features AVP is the loss algorithm, the reacting node MUST apply abatement treatment to the requested percentage of request messages sent.

Note: The loss algorithm is a stateless algorithm. As a result, the reacting node does not guarantee that there will be an absolute reduction in traffic sent. Rather, it guarantees that the requested percentage of new requests will be given abatement treatment.

If the reacting node comes out of the 100% traffic reduction (meaning, it has received an OLR indicating that no traffic should be sent, as a result of the overload report timing out), the reacting node sending the traffic SHOULD be conservative and, for example, first send "probe" messages to learn the overload condition of the overloaded node before converging to any traffic amount/rate decided by the sender. Similar concerns apply in all cases when the overload report times out, unless the previous overload report stated 0% reduction.

Note: The goal of this behavior is to reduce the probability of overload condition thrashing where an immediate transition from 100% reduction to 0% reduction results in the reporting node moving quickly back into an overload condition.

7. Attribute Value Pairs

This section describes the encoding and semantics of the Diameter Overload Indication Attribute Value Pairs (AVPs) defined in this document.

Refer to Section 4 of [RFC6733] for more information on AVPs and AVP data types.

7.1. OC-Supported-Features AVP

The OC-Supported-Features AVP (AVP Code 621) is of type Grouped and serves two purposes. First, it announces a node's support for the DOIC solution in general. Second, it contains the description of the supported DOIC features of the sending node. The OC-Supported-Features AVP MUST be included in every Diameter request message a DOIC supporting node sends.

```
OC-Supported-Features ::= < AVP Header: 621 >
                        [ OC-Feature-Vector ]
                        * [ AVP ]
```

7.2. OC-Feature-Vector AVP

The OC-Feature-Vector AVP (AVP Code 622) is of type Unsigned64 and contains a 64-bit flags field of announced capabilities of a DOIC node. The value of zero (0) is reserved.

The OC-Feature-Vector sub-AVP is used to announce the DOIC features supported by the DOIC node, in the form of a flag-bits field in which each bit announces one feature or capability supported by the node. The absence of the OC-Feature-Vector AVP in request messages indicates that only the default traffic abatement algorithm described in this specification is supported. The absence of the OC-Feature-Vector AVP in answer messages indicates that the default traffic abatement algorithm described in this specification is selected (while other traffic abatement algorithms may be supported), and no features other than abatement algorithms are supported.

The following capability is defined in this document:

OLR_DEFAULT_ALGO (0x0000000000000001)

When this flag is set by the a DOIC reacting node, it means that the default traffic abatement (loss) algorithm is supported. When this flag is set by a DOIC reporting node, it means that the loss algorithm will be used for requested overload abatement.

7.3. OC-OLR AVP

The OC-OLR AVP (AVP Code 623) is of type Grouped and contains the information necessary to convey an overload report on an overload condition at the reporting node. The application the OC-OLR AVP applies to is identified by the Application-ID found in the Diameter message header. The host or realm the OC-OLR AVP concerns is determined from the Origin-Host AVP and/or Origin-Realm AVP found in the encapsulating Diameter command. The OC-OLR AVP is intended to be sent only by a reporting node.

```
OC-OLR ::= < AVP Header: 623 >
          < OC-Sequence-Number >
          < OC-Report-Type >
          [ OC-Reduction-Percentage ]
          [ OC-Validity-Duration ]
          * [ AVP ]
```

7.4. OC-Sequence-Number AVP

The OC-Sequence-Number AVP (AVP Code 624) is of type Unsigned64. Its usage in the context of overload control is described in Section 5.2.

From the functionality point of view, the OC-Sequence-Number AVP is used as a nonvolatile increasing counter for a sequence of overload reports between two DOIC nodes for the same overload occurrence. Sequence numbers are treated in a unidirectional manner, i.e., two sequence numbers in each direction between two DOIC nodes are not related or correlated.

7.5. OC-Validity-Duration AVP

The OC-Validity-Duration AVP (AVP Code 625) is of type Unsigned32 and indicates in seconds the validity time of the overload report. The number of seconds is measured after reception of the first OC-OLR AVP with a given value of OC-Sequence-Number AVP. The default value for the OC-Validity-Duration AVP is 30 seconds. When the OC-Validity-Duration AVP is not present in the OC-OLR AVP, the default value applies. The maximum value for the OC-Validity-Duration AVP is

86,400 seconds (24 hours). If the value received in the OC-Validity-Duration is greater than the maximum value, then the default value applies.

7.6. OC-Report-Type AVP

The OC-Report-Type AVP (AVP Code 626) is of type Enumerated. The value of the AVP describes what the overload report concerns. The following values are initially defined:

HOST_REPORT 0

The overload report is for a host. Overload abatement treatment applies to host-routed requests.

REALM_REPORT 1

The overload report is for a realm. Overload abatement treatment applies to realm-routed requests.

The values 2-4294967295 are unassigned.

7.7. OC-Reduction-Percentage AVP

The OC-Reduction-Percentage AVP (AVP Code 627) is of type Unsigned32 and describes the percentage of the traffic that the sender is requested to reduce, compared to what it otherwise would send. The OC-Reduction-Percentage AVP applies to the default (loss) algorithm specified in this specification. However, the AVP can be reused for future abatement algorithms, if its semantics fit into the new algorithm.

The value of the Reduction-Percentage AVP is between zero (0) and one hundred (100). Values greater than 100 are ignored. The value of 100 means that all traffic is to be throttled, i.e., the reporting node is under a severe load and ceases to process any new messages. The value of 0 means that the reporting node is in a stable state and has no need for the reacting node to apply any traffic abatement.

7.8. AVP Flag Rules

Attribute Name	AVP Code	Section Defined	Value Type	AVP flag rules	
				MUST	NOT
OC-Supported-Features	621	7.1	Grouped		V
OC-Feature-Vector	622	7.2	Unsigned64		V
OC-OLR	623	7.3	Grouped		V
OC-Sequence-Number	624	7.4	Unsigned64		V
OC-Validity-Duration	625	7.5	Unsigned32		V
OC-Report-Type	626	7.6	Enumerated		V
OC-Reduction -Percentage	627	7.7	Unsigned32		V

As described in the Diameter base protocol [RFC6733], the M-bit usage for a given AVP in a given command may be defined by the application.

8. Error Response Codes

When a DOIC node rejects a Diameter request due to overload, the DOIC node MUST select an appropriate error response code. This determination is made based on the probability of the request succeeding if retried on a different path.

Note: This only applies for DOIC nodes that are not the originator of the request.

A reporting node rejecting a Diameter request due to an overload condition SHOULD send a `DIAMETER_TOO_BUSY` error response, if it can assume that the same request may succeed on a different path.

If a reporting node knows or assumes that the same request will not succeed on a different path, the `DIAMETER_UNABLE_TO_COMPLY` error response SHOULD be used. Retrying would consume valuable resources during an occurrence of overload.

For instance, if the request arrived at the reporting node without a Destination-Host AVP, then the reporting node might determine that there is an alternative Diameter node that could successfully process the request and that retrying the transaction would not negatively impact the reporting node. `DIAMETER_TOO_BUSY` would be sent in this case.

If the request arrived at the reporting node with a Destination-Host AVP populated with its own Diameter identity, then the reporting node can assume that retrying the request would result in it coming to the same reporting node. `DIAMETER_UNABLE_TO_COMPLY` would be sent in this case.

A second example is when an agent that supports the DOIC solution is performing the role of a reacting node for a non-supporting client. Requests that are rejected as a result of DOIC throttling by the agent in this scenario would generally be rejected with a `DIAMETER_UNABLE_TO_COMPLY` response code.

9. IANA Considerations

9.1. AVP Codes

New AVPs defined by this specification are listed in Section 7. All AVP codes are allocated from the "AVP Codes" sub-registry under the "Authentication, Authorization, and Accounting (AAA) Parameters" registry.

9.2. New Registries

Two new registries have been created in the "AVP Specific Values" sub-registry under the "Authentication, Authorization, and Accounting (AAA) Parameters" registry.

A new "OC-Feature-Vector AVP Values (code 622)" registry has been created. This registry contains the following:

Feature Vector Value Name

Feature Vector Value

Specification defining the new value

See Section 7.2 for the initial Feature Vector Value in the registry. This specification defines the value. New values can be added to the registry using the Specification Required policy [RFC5226].

A new "OC-Report-Type AVP Values (code 626)" registry has been created. This registry contains the following:

Report Type Value Name

Report Type Value

Specification defining the new value

See Section 7.6 for the initial assignment in the registry. New types can be added using the Specification Required policy [RFC5226].

10. Security Considerations

DOIC gives Diameter nodes the ability to request that downstream nodes send fewer Diameter requests. Nodes do this by exchanging overload reports that directly effect this reduction. This exchange is potentially subject to multiple methods of attack and has the potential to be used as a denial-of-service (DoS) attack vector. For instance, a series of injected realm OLRs with a requested reduction percentage of 100% could be used to completely eliminate any traffic from being sent to that realm.

Overload reports may contain information about the topology and current status of a Diameter network. This information is potentially sensitive. Network operators may wish to control disclosure of overload reports to unauthorized parties to avoid their use for competitive intelligence or to target attacks.

Diameter does not include features to provide end-to-end authentication, integrity protection, or confidentiality. This may cause complications when sending overload reports between non-adjacent nodes.

10.1. Potential Threat Modes

The Diameter protocol involves transactions in the form of requests and answers exchanged between clients and servers. These clients and servers may be peers, that is, they may share a direct transport (e.g., TCP or SCTP) connection, or the messages may traverse one or more intermediaries, known as Diameter Agents. Diameter nodes use TLS, DTLS, or IPsec to authenticate peers and to provide confidentiality and integrity protection of traffic between peers. Nodes can make authorization decisions based on the peer identities authenticated at the transport layer.

When agents are involved, this presents an effectively transitive trust model. That is, a Diameter client or server can authorize an agent for certain actions, but it must trust that agent to make appropriate authorization decisions about its peers, and so on. Since confidentiality and integrity protection occur at the transport layer, agents can read, and perhaps modify, any part of a Diameter message, including an overload report.

There are several ways an attacker might attempt to exploit the overload control mechanism. An unauthorized third party might inject an overload report into the network. If this third party is upstream of an agent, and that agent fails to apply proper authorization policies, downstream nodes may mistakenly trust the report. This attack is at least partially mitigated by the assumption that nodes include overload reports in Diameter answers but not in requests. This requires an attacker to have knowledge of the original request in order to construct an answer. Such an answer would also need to arrive at a Diameter node via a protected transport connection. Therefore, implementations MUST validate that an answer containing an overload report is a properly constructed response to a pending request prior to acting on the overload report, and that the answer was received via an appropriate transport connection.

A similar attack involves a compromised but otherwise authorized node that sends an inappropriate overload report. For example, a server for the realm "example.com" might send an overload report indicating that a competitor's realm "example.net" is overloaded. If other nodes act on the report, they may falsely believe that "example.net" is overloaded, effectively reducing that realm's capacity. Therefore, it's critical that nodes validate that an overload report received from a peer actually falls within that peer's responsibility before acting on the report or forwarding the report to other peers. For example, an overload report from a peer that applies to a realm not handled by that peer is suspect. This may require out-of-band, non-Diameter agreements and/or mechanisms.

This attack is partially mitigated by the fact that the application, as well as host and realm, for a given OLR is determined implicitly by respective AVPs in the enclosing answer. If a reporting node modifies any of those AVPs, the enclosing transaction will also be affected.

10.2. Denial-of-Service Attacks

Diameter overload reports, especially realm reports, can cause a node to cease sending some or all Diameter requests for an extended period. This makes them a tempting vector for DoS attacks. Furthermore, since Diameter is almost always used in support of other

protocols, a DoS attack on Diameter is likely to impact those protocols as well. In the worst case, where the Diameter application is being used for access control into an IP network, a coordinated DoS attack could result in the blockage of all traffic into that network. Therefore, Diameter nodes MUST NOT honor or forward OLRs received from peers that are not trusted to send them.

An attacker might use the information in an OLR to assist in DoS attacks. For example, an attacker could use information about current overload conditions to time an attack for maximum effect, or use subsequent overload reports as a feedback mechanism to learn the results of a previous or ongoing attack. Operators need the ability to ensure that OLRs are not leaked to untrusted parties.

10.3. Noncompliant Nodes

In the absence of an overload control mechanism, Diameter nodes need to implement strategies to protect themselves from floods of requests, and to make sure that a disproportionate load from one source does not prevent other sources from receiving service. For example, a Diameter server might throttle a certain percentage of requests from sources that exceed certain limits. Overload control can be thought of as an optimization for such strategies, where downstream nodes never send the excess requests in the first place. However, the presence of an overload control mechanism does not remove the need for these other protection strategies.

When a Diameter node sends an overload report, it cannot assume that all nodes will comply, even if they indicate support for DOIC. A noncompliant node might continue to send requests with no reduction in load. Such noncompliance could be done accidentally or maliciously to gain an unfair advantage over compliant nodes. Requirement 28 in [RFC7068] indicates that the overload control solution cannot assume that all Diameter nodes in a network are trusted. It also requires that malicious nodes not be allowed to take advantage of the overload control mechanism to get more than their fair share of service.

10.4. End-to-End Security Issues

The lack of end-to-end integrity features makes it difficult to establish trust in overload reports received from non-adjacent nodes. Any agents in the message path may insert or modify overload reports. Nodes must trust that their adjacent peers perform proper checks on overload reports from their peers, and so on, creating a transitive-trust requirement extending for potentially long chains of nodes. Network operators must determine if this transitive trust requirement is acceptable for their deployments. Nodes supporting Diameter

overload control MUST give operators the ability to select which peers are trusted to deliver overload reports and whether they are trusted to forward overload reports from non-adjacent nodes. DOIC nodes MUST strip DOIC AVPs from messages received from peers that are not trusted for DOIC purposes.

The lack of end-to-end confidentiality protection means that any Diameter Agent in the path of an overload report can view the contents of that report. In addition to the requirement to select which peers are trusted to send overload reports, operators MUST be able to select which peers are authorized to receive reports. A node MUST NOT send an overload report to a peer not authorized to receive it. Furthermore, an agent MUST remove any overload reports that might have been inserted by other nodes before forwarding a Diameter message to a peer that is not authorized to receive overload reports.

A DOIC node cannot always automatically detect that a peer also supports DOIC. For example, a node might have a peer that is a non-supporting agent. If nodes on the other side of that agent send OC-Supported-Features AVPs, the agent is likely to forward them as unknown AVPs. Messages received across the non-supporting agent may be indistinguishable from messages received across a DOIC supporting agent, giving the false impression that the non-supporting agent actually supports DOIC. This complicates the transitive-trust nature of DOIC. Operators need to be careful to avoid situations where a non-supporting agent is mistakenly trusted to enforce DOIC-related authorization policies.

It is expected that work on end-to-end Diameter security might make it easier to establish trust in non-adjacent nodes for overload control purposes. Readers should be reminded, however, that the overload control mechanism allows Diameter Agents to modify AVPs in, or insert additional AVPs into, existing messages that are originated by other nodes. If end-to-end security is enabled, there is a risk that such modification could violate integrity protection. The details of using any future Diameter end-to-end security mechanism with overload control will require careful consideration, and are beyond the scope of this document.

11. References

11.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <<http://www.rfc-editor.org/info/rfc2119>>.
- [RFC5226] Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 5226, DOI 10.17487/RFC5226, May 2008, <<http://www.rfc-editor.org/info/rfc5226>>.
- [RFC6733] Fajardo, V., Ed., Arkko, J., Loughney, J., and G. Zorn, Ed., "Diameter Base Protocol", RFC 6733, DOI 10.17487/RFC6733, October 2012, <<http://www.rfc-editor.org/info/rfc6733>>.

11.2. Informative References

- [Cx] 3GPP, "Cx and Dx interfaces based on the Diameter protocol; Protocol details", 3GPP TS 29.229 12.7.0, September 2015.
- [PCC] 3GPP, "Policy and charging control architecture", 3GPP TS 23.203 12.10.0, September 2015.
- [RFC4006] Hakala, H., Mattila, L., Koskinen, J-P., Stura, M., and J. Loughney, "Diameter Credit-Control Application", RFC 4006, DOI 10.17487/RFC4006, August 2005, <<http://www.rfc-editor.org/info/rfc4006>>.
- [RFC7068] McMurry, E. and B. Campbell, "Diameter Overload Control Requirements", RFC 7068, DOI 10.17487/RFC7068, November 2013, <<http://www.rfc-editor.org/info/rfc7068>>.
- [S13] 3GPP, "Evolved Packet System (EPS); Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) related interfaces based on Diameter protocol", 3GPP TS 29.272 12.8.0, September 2015.

Appendix A. Issues Left for Future Specifications

The base solution for overload control does not cover all possible use cases. A number of solution aspects were intentionally left for future specification and protocol work. The following subsections define some of the potential extensions to the DOIC solution.

A.1. Additional Traffic Abatement Algorithms

This specification describes only means for a simple loss-based algorithm. Future algorithms can be added using the designed solution extension mechanism. The new algorithms need to be registered with IANA. See Sections 7.2 and 9 for the required IANA steps.

A.2. Agent Overload

This specification focuses on Diameter endpoint (server or client) overload. A separate extension will be required to outline the handling of the case of agent overload.

A.3. New Error Diagnostic AVP

This specification indicates the use of existing error messages when nodes reject requests due to overload. There is an expectation that additional error codes or AVPs will be defined in a separate specification to indicate that overload was the reason for the rejection of the message.

Appendix B. Deployment Considerations

Non-supporting Agents

Due to the way that realm-routed requests are handled in Diameter networks with the server selection for the request done by an agent, network operators should enable DOIC at agents that perform server selection first.

Topology-Hiding Interactions

There exist proxies that implement what is referred to as Topology Hiding. This can include cases where the agent modifies the Origin-Host in answer messages. The behavior of the DOIC solution is not well understood when this happens. As such, the DOIC solution does not address this scenario.

Inter-Realm/Administrative Domain Considerations

There are likely to be special considerations for handling DOIC signaling across administrative boundaries. This includes considerations for whether or not information included in the DOIC signaling should be sent across those boundaries. In addition, consideration should be taken as to whether or not a reacting node in one realm can be trusted to implement the requested overload abatement handling for overload reports received from a separately administered realm.

Appendix C. Considerations for Applications Integrating the DOIC Solution

This section outlines considerations to be taken into account when integrating the DOIC solution into Diameter applications.

C.1. Application Classification

The following is a classification of Diameter applications and request types. This discussion is meant to document factors that play into decisions made by the Diameter entity responsible for handling overload reports.

Section 8.1 of [RFC6733] defines two state machines that imply two types of applications, session-less and session-based applications. The primary difference between these types of applications is the lifetime of Session-Ids.

For session-based applications, the Session-Id is used to tie multiple requests into a single session.

The Credit-Control application defined in [RFC4006] is an example of a Diameter session-based application.

In session-less applications, the lifetime of the Session-Id is a single Diameter transaction, i.e., the session is implicitly terminated after a single Diameter transaction and a new Session-Id is generated for each Diameter request.

For the purposes of this discussion, session-less applications are further divided into two types of applications:

Stateless Applications:

Requests within a stateless application have no relationship to each other. The 3GPP-defined S13 application is an example of a stateless application [S13], where only a Diameter command is defined between a client and a server and no state is maintained between two consecutive transactions.

Pseudo-Session Applications:

Applications that do not rely on the Session-Id AVP for correlation of application messages related to the same session but use other session-related information in the Diameter requests for this purpose. The 3GPP-defined Cx application [Cx] is an example of a pseudo-session application.

The handling of overload reports must take the type of application into consideration, as discussed in Appendix C.2.

C.2. Implications of Application Type Overload

This section discusses considerations for mitigating overload reported by a Diameter entity. This discussion focuses on the type of application. Appendix C.3 discusses considerations for handling various request types when the target server is known to be in an overloaded state.

These discussions assume that the strategy for mitigating the reported overload is to reduce the overall workload sent to the overloaded entity. The concept of applying overload treatment to requests targeted for an overloaded Diameter entity is inherent to this discussion. The method used to reduce offered load is not specified here, but it could include routing requests to another Diameter entity known to be able to handle them, or it could mean rejecting certain requests. For a Diameter Agent, rejecting requests will usually mean generating appropriate Diameter error responses. For a Diameter client, rejecting requests will depend upon the application. For example, it could mean giving an indication to the entity requesting the Diameter service that the network is busy and to try again later.

Stateless Applications:

By definition, there is no relationship between individual requests in a stateless application. As a result, when a request is sent or relayed to an overloaded Diameter entity -- either a Diameter Server or a Diameter Agent -- the sending or relaying entity can choose to apply the overload treatment to any request targeted for the overloaded entity.

Pseudo-session Applications:

For pseudo-session applications, there is an implied ordering of requests. As a result, decisions about which requests towards an overloaded entity to reject could take the command code of the request into consideration. This generally means that transactions later in the sequence of transactions should be given more favorable treatment than messages earlier in the sequence. This is because more work has already been done by the Diameter network for those transactions that occur later in the sequence. Rejecting them could result in increasing the load on the network as the transactions earlier in the sequence might also need to be repeated.

Session-Based Applications:

Overload handling for session-based applications must take into consideration the work load associated with setting up and maintaining a session. As such, the entity sending requests towards an overloaded Diameter entity for a session-based application might tend to reject new session requests prior to rejecting intra-session requests. In addition, session-ending requests might be given a lower probability of being rejected, as rejecting session-ending requests could result in session status being out of sync between the Diameter clients and servers. Application designers that would decide to reject mid-session requests will need to consider whether the rejection invalidates the session and any resulting session cleanup procedures.

C.3. Request Transaction Classification

Independent Request:

An independent request is not correlated to any other requests, and, as such, the lifetime of the Session-Id is constrained to an individual transaction.

Session-Initiating Request:

A session-initiating request is the initial message that establishes a Diameter session. The ACR message defined in [RFC6733] is an example of a session-initiating request.

Correlated Session-Initiating Request:

There are cases when multiple session-initiated requests must be correlated and managed by the same Diameter server. It is notably the case in the 3GPP Policy and Charging Control (PCC) architecture [PCC], where multiple apparently independent Diameter application sessions are actually correlated and must be handled by the same Diameter server.

Intra-session Request:

An intra-session request is a request that uses the same Session-Id as the one used in a previous request. An intra-session request generally needs to be delivered to the server that handled the session-creating request for the session. The STR message defined in [RFC6733] is an example of an intra-session request.

Pseudo-session Requests:

Pseudo-session requests are independent requests and do not use the same Session-Id but are correlated by other session-related information contained in the request. There exist Diameter applications that define an expected ordering of transactions. This sequencing of independent transactions results in a pseudo-session. The AIR, MAR, and SAR requests in the 3GPP-defined Cx [Cx] application are examples of pseudo-session requests.

C.4. Request Type Overload Implications

The request classes identified in Appendix C.3 have implications on decisions about which requests should be throttled first. The following list of request treatments regarding throttling is provided as guidelines for application designers when implementing the Diameter overload control mechanism described in this document. The exact behavior regarding throttling is a matter of local policy, unless specifically defined for the application.

Independent Requests:

Independent requests can generally be given equal treatment when making throttling decisions, unless otherwise indicated by application requirements or local policy.

Session-Initiating Requests:

Session-initiating requests often represent more work than independent or intra-session requests. Moreover, session-initiating requests are typically followed by other session-related requests. Since the main objective of overload control is to reduce the total number of requests sent to the overloaded entity, throttling decisions might favor allowing intra-session requests over session-initiating requests. In the absence of local policies or application-specific requirements to the contrary, individual session-initiating requests can be given equal treatment when making throttling decisions.

Correlated Session-Initiating Requests:

A request that results in a new binding; where the binding is used for routing of subsequent session-initiating requests to the same server, it represents more work load than other requests. As such, these requests might be throttled more frequently than other request types.

Pseudo-session Requests:

Throttling decisions for pseudo-session requests can take into consideration where individual requests fit into the overall sequence of requests within the pseudo-session. Requests that are earlier in the sequence might be throttled more aggressively than requests that occur later in the sequence.

Intra-session Requests:

There are two types of intra-sessions requests, requests that terminate a session and the remainder of intra-session requests. Implementers and operators may choose to throttle session-terminating requests less aggressively in order to gracefully terminate sessions, allow cleanup of the related resources (e.g., session state), and avoid the need for additional intra-session requests. Favoring session termination requests may reduce the session management impact on the overloaded entity. The default handling of other intra-session requests might be to treat them equally when making throttling decisions. There might also be application-level considerations whether some request types are favored over others.

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