Diameter Maintenance and Extensions (DIME)
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J. Korhonen, Ed.
Broadcom
S. Donovan
B. Campbell
Oracle
L. Morand
Orange Labs

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Diameter Overload Indication Conveyance
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Abstract

This specification documents a Diameter Overload Control (DOC) base solution and the dissemination of the overload report information.

Requirements

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

Status of this Memo

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1. Introduction

This specification defines a base solution for Diameter Overload Control (DOC). The requirements for the solution are described and discussed in the corresponding design requirements document [RFC7068]. Note that the overload control solution defined in this specification does not address all the requirements listed in [RFC7068]. A number of overload control related features are left for the future specifications.

The solution defined in this specification addresses the Diameter overload control between two endpoints (see Section 5.1). Furthermore, the solution 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.

2. Terminology and Abbreviations

Server Farm

A set of Diameter servers that can handle any request for a given set of Diameter applications. While these servers support the same set of applications, they do not necessarily all have the same capacity. An individual server farm might also support a subset of the users for a Diameter Realm. A server farm may host a single or multiple realms.

Diameter Routing:

Diameter Routing between non-adjacent nodes relies on the Destination-Realm AVP to determine the Diameter realm in which the request needs to be processed. A Destination-Host AVP may also be present in the request to address a specific server inside the Diameter realm. This function is defined in [RFC6733]. However, it is possible to enhance the routing decisions with application level knowledge as it done in 3GPP PCC [3GPP.23.203] and NAI-based source routing [RFC5729].

Diameter layer Load Balancing:

Diameter layer load balancing allows Diameter requests to be distributed across the set of servers. Definition of this function is outside the scope of this document.

Topology Hiding:

Topology Hiding is loosely defined as ensuring that no Diameter topology information about a Diameter network can be discovered from Diameter messages sent outside a predefined boundary (typically an administrative domain). This includes obfuscating identifiers and address information of Diameter entities in the Diameter network. It can also include hiding the number of various Diameter entities in the Diameter network. Identifying information can occur in many Diameter Attribute-Value Pairs (AVPs), including Origin-Host, Destination-Host, Route-Record, Proxy-Info, Session-ID and other AVPs.

Throttling:

Throttling is the reduction of the number of requests sent to an entity. Throttling can include a client dropping requests, or an agent rejecting requests with appropriate error responses. Clients and agents can also choose to redirect throttled requests to some other entity or entities capable of handling them.

Reporting Node

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

Reacting Node

A Diameter node that consumes and acts upon a report. Note that "act upon" does not necessarily mean the reacting node applies an abatement algorithm; it might decide to delegate that downstream, in which case it also becomes a "reporting node".

OLR Overload Report.

3. Solution Overview

3.1. Architectural Assumptions

This section describes the high-level architectural and semantic assumptions that underlie the Diameter Overload Control Mechanism.

3.1.1. Application Classification

The following is a classification of Diameter applications and requests. This discussion is meant to document factors that play into decisions made by the Diameter identity 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.

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 [3GPP.29.272], 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 [3GPP.29.229] is an example of a pseudo-session application.

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

The handling of overload reports must take the type of application into consideration, as discussed in Section 3.1.2.

3.1.2. Application Type Overload Implications

This section discusses considerations for mitigating overload reported by a Diameter entity. This discussion focuses on the type of application. Section 3.1.3 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 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 clean-up procedures.

3.1.3. 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 PCC architecture [3GPP.23.203], 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 than 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 requests.

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 exists 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 application are examples of pseudo-session requests.

3.1.4. Request Type Overload Implications

The request classes identified in Section 3.1.3 have implications on decisions about which requests should be throttled first. The following list of request treatment regarding throttling is provided as guidelines for application designers when implementing the Diameter overload control mechanism described in this document. Exact behavior regarding throttling must be defined per application.

Independent requests:

Independent requests can be given equal treatment when making throttling decisions.

Session-initiating requests:

Session-initiating requests represent more work than independent or intra-session requests. Moreover, session-initiating requests are typically followed by other related session-related requests. As such, as the main objective of the 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. 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, 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 classes of intra-sessions requests. The first class consists of requests that terminate a session. The second one contains the set of requests that are used by the Diameter client and server to maintain the ongoing session state. Session

terminating requests should be throttled less aggressively in order to gracefully terminate sessions, allow clean-up of the related resources (e.g. session state) and get rid of the need for other intra-session requests, reducing 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.

3.1.5. Diameter Agent Behaviour

In the context of the Diameter Overload Indication Conveyance (DOIC) and reacting to the overload information, the functional behaviour of Diameter agents in front of servers, especially Diameter proxies, needs to be common. This is important because agents may actively participate in the handling of an overload conditions. For example, they may make intelligent next hop selection decisions based on overload conditions, or aggregate overload information to be disseminated downstream. Diameter agents may have other deployment related tasks that are not defined in the Diameter base protocol [RFC6733]. These include, among other tasks, topology hiding, or agent acting as a Server Front End (SFE) for a farm of Diameter servers.

Since the solution defined in this specification must not break the Diameter base protocol [RFC6733] at any time, great care has to be taken not to assume functionality from the Diameter agents that would break base protocol behavior, or to assume agent functionality beyond the Diameter base protocol. Effectively this means the following from a Diameter agent:

- If a Diameter agent presents itself as the "end node", as an agent acting as an topology hiding SFE, the agent is the final destination of requests initiated by Diameter clients, the original source for the corresponding answers and server-initiated requests. As a consequence, the DOIC mechanism MUST NOT leak information of the Diameter nodes behind it. This requirement means that such a Diameter agent acts as a back-to-back-agent for DOIC purposes. How the Diameter agent in this case appears to the Diameter servers in the farm, is specific to the implementation and deployment within the realm the Diameter agent is deployed.

- If the Diameter agent does not impersonate the servers behind it, the Diameter dialogue is established between clients and servers and any overload information received by a client would be from the server identified by the Origin-Host identity contained in the Diameter message.

3.1.6. Simplified Example Architecture

Figure 1 illustrates the simplified architecture for Diameter overload information conveyance. See Section 5.1 for more discussion and details how different Diameter nodes fit into the architecture from the DOIC point of view.

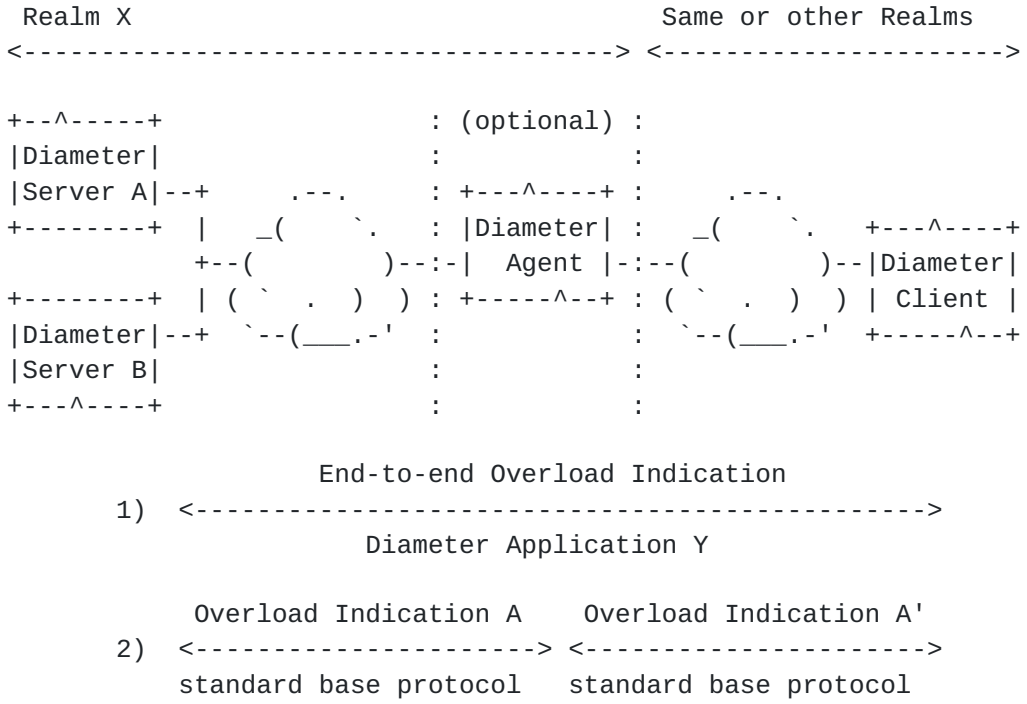

Figure 1: Simplified architecture choices for overload indication delivery

In Figure 1, the Diameter overload indication can be conveyed (1) end-to-end between servers and clients or (2) between servers and Diameter agent inside the realm and then between the Diameter agent and the clients when the Diameter agent acting as back-to-back-agent for DOIC purposes.

3.2. Conveyance of the Overload Indication

The following sections describe new Diameter AVPs used for sending overload reports, and for declaring support for certain DOIC features.

3.2.1. DOIC Capability Discovery

Support of DOIC may be specified as part of the functionality supported by a new Diameter application. In this way, support of the considered Diameter application (discovered during capabilities exchange phase as defined in Diameter base protocol [RFC6733]) indicates implicit support of the DOIC mechanism.

When the DOIC mechanism is introduced in existing Diameter applications, a specific capability discovery mechanism is required. The "DOIC capability discovery mechanism" is based on the presence of specific optional AVPs in the Diameter messages, such as the OC-Supported-Features AVP (see Section 4.1). Although the OC-Supported-Features AVP can be used to advertise a certain set of new or existing Diameter overload control capabilities, it is not a versioning solution per se, however, it can be used to achieve the same result.

From the Diameter overload control functionality point of view, the "Reacting node" is the requester of the overload report information and the "Reporting node" is the provider of the overload report. The OC-Supported-Features AVP in the request message is always interpreted as an announcement of "DOIC supported capabilities". The OC-Supported-Features AVP in the answer is also interpreted as a report of "DOIC supported capabilities" and at least one of supported capabilities MUST be common with the "Reacting node" (see Section 4.1).

3.3. Overload Condition Indication

Diameter nodes can request a reduction in offered load by indicating an overload condition in the form of an overload report. The overload report contains information about how much load should be reduced, and may contain other information about the overload condition. This information is conveyed in Diameter Attribute Value Pairs (AVPs).

Certain new AVPs may also be used to declare certain DOIC capabilities and extensions.

4. Attribute Value Pairs

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

4.1. OC-Supported-Features AVP

The OC-Supported-Features AVP (AVP code TBD1) is type of Grouped and serves for two purposes. First, it announces node's support for the DOIC in general. Second, it contains the description of the supported DOIC features of the sending node. The OC-Supported-Features AVP SHOULD be included into every Diameter message a DOIC supporting node sends (and intends to use for DOIC purposes).

```
OC-Supported-Features ::= < AVP Header: TBD1 >
                          < OC-Sequence-Number >
                          [ OC-Feature-Vector ]
                         * [ AVP ]
```

The OC-Sequence-Number AVP is used to indicate whether the contents of the OC-Supported-Features AVP has changed since last time the node included the OC-Supported-Features AVP (see Section 4.4). Although sending the OC-Sequence-Number AVP is mandatory in the OC-Supported-Features AVP, the receiving node MAY always choose to ignore the sequence number if it can determine the feature support changes otherwise.

The OC-Feature-Vector sub-AVP is used to announced the DOIC features supported by the endpoint, in the form of a flag bits field in which each bit announces one feature or capability supported by the node (see Section 4.2). The absence of the OC-Feature-Vector AVP indicates that only the default traffic abatement algorithm described in this specification is supported.

A reacting node includes this AVP to indicate its capabilities to a reporting node. For example, the endpoint (reacting node) may indicate which (future defined) traffic abatement algorithms it supports in addition to the default.

During the message exchange the overload control endpoints express their common set of supported capabilities. The reacting node includes the OC-Supported-Features AVP that announces what it supports. The reporting node that sends the answer also includes the OC-Supported-Features AVP that describes the capabilities it supports. The set of capabilities advertised by the reporting node depends on local policies. At least one of the announced capabilities MUST match mutually. If there is no single matching capability the reacting node MUST act as if it does not implement DOIC and cease inserting any DOIC related AVPs into any Diameter messages with this specific reacting node.

4.2. OC-Feature-Vector AVP

The OC-Feature-Vector AVP (AVP code TBD6) is type of Unsigned64 and contains a 64 bit flags field of announced capabilities of an overload control endpoint. The value of zero (0) is reserved.

The following capabilities are defined in this document:

OLR_DEFAULT_ALGO (0x0000000000000001)

When this flag is set by the overload control endpoint it means that the default traffic abatement (loss) algorithm is supported.

4.3. OC-OLR AVP

The OC-OLR AVP (AVP code TBD2) is type of Grouped and contains the necessary information to convey an overload report. The OC-OLR AVP does not contain explicit information to which application it applies to and who inserted the AVP or whom the specific OC-OLR AVP concerns to. Both these information is implicitly learned from the encapsulating Diameter message/command. The application the OC-OLR AVP applies to is the same as the Application-Id found in the Diameter message header. The identity the OC-OLR AVP concerns is determined from the Origin-Host AVP (and Origin-Realm AVP as well) found from the encapsulating Diameter command. The OC-OLR AVP is intended to be sent only by a reporting node.

```
OC-OLR ::= < AVP Header: TBD2 >
           < OC-Sequence-Number >
           [ OC-Report-Type ]
           [ OC-Reduction-Percentage ]
           [ OC-Validity-Duration ]
         * [ AVP ]
```

The Sequence-Number AVP indicates the "freshness" of the OC-OLR AVP. It is possible to replay the same OC-OLR AVP multiple times between the overload control endpoints, however, when the OC-OLR AVP content changes or sending endpoint otherwise wants the receiving endpoint to update its overload control information, then the OC-Sequence-Number AVP MUST contain a new greater value than the previously received. The receiver SHOULD discard an OC-OLR AVP with a sequence number that is less than previously received one.

Note that if a Diameter command were to contain multiple OC-OLR AVPs they all MUST have different OC-Report-Type AVP value. OC-OLR AVPs with unknown values SHOULD be silently discarded and the event SHOULD be logged.

The OC-OLR AVP can be expanded with optional sub-AVPs only if a legacy implementation can safely ignore them without breaking backward compatibility for the given OC-Report-Type AVP value implied report handling semantics. If the new sub-AVPs imply new semantics for the report handling, then a new OC-Report-Type AVP value MUST be defined.

4.4. OC-Sequence-Number AVP

The OC-Sequence-Number AVP (AVP code TBD3) is type of Time. Its usage in the context of the overload control is described in Sections 4.1 and 4.3.

From the functionality point of view, the OC-Sequence-Number AVP MUST be used as a non-volatile increasing counter between two overload control endpoints (neglecting the fact that the contents of the AVP is a 64-bit NTP timestamp [RFC5905]). The sequence number is only required to be unique between two overload control endpoints. Sequence numbers are treated in uni-directional manner, i.e. two sequence numbers on each direction between two endpoints are not related or correlated.

When generating sequence numbers, the new sequence number MUST be greater than any sequence number previously seen between two endpoints within a time window that tolerates the wraparound of the NTP timestamp (i.e. approximately 68 years).

4.5. OC-Validity-Duration AVP

The OC-Validity-Duration AVP (AVP code TBD4) is type of Unsigned32 and describes the number of seconds the "new and fresh" OC-OLR AVP and its content is valid since the reception of the new OC-OLR AVP. The default value for the OC-Validity-Duration AVP value is 5 (i.e., 5 seconds). When the OC-Validity-Duration AVP is not present in the OC-OLR AVP, the default value applies. Validity duration values 0 (i.e., 0 seconds) and above 86400 (i.e., 24 hours) MUST NOT be used. Invalid validity duration values are treated as if the OC-Validity-Duration AVP were not present.

A timeout of the overload report has specific concerns that need to be taken into account by the endpoint acting on the earlier received overload report(s). Section 4.7 discusses the impacts of timeout in the scope of the traffic abatement algorithms.

As a general guidance for implementations it is RECOMMENDED never to let any overload report to timeout. Following to this rule, an overload endpoint should explicitly signal the end of overload condition and not rely on the expiration of the validity time of the

overload report in the reacting node. This leaves no need for the reacting node to reason or guess the overload condition of the reporting node.

4.6. OC-Report-Type AVP

The OC-Report-Type AVP (AVP code TBD5) is type of Enumerated. The value of the AVP describes what the overload report concerns. The following values are initially defined:

0 A host report. The overload treatment should apply to requests the reacting node knows that will reach the overloaded node. For example, requests with a Destination-Host AVP indicating the endpoint. The reacting node learns the "host" implicitly from the Origin-Host AVP of the received message that contained the OC-OLR AVP.

1 A realm report. The overload treatment should apply to all requests bound for the overloaded realm. The reacting node learns the "realm" implicitly from the Origin-Realm AVP of the received message that contained the OC-OLR AVP.

The default value of the OC-Report-Type AVP is 0 (i.e. the host report).

The OC-Report-Type AVP is envisioned to be useful for situations where a reacting node needs to apply different overload treatments for different "types" of overload. For example, the reacting node(s) might need to throttle differently requests sent to a specific server (identified by the Destination-Host AVP in the request) and requests that can be handled by any server in a realm. The example in Appendix B.1 illustrates this usage.

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 specification MUST also reserve a corresponding new feature, see the OC-Supported-Features and OC-Feature-Vector AVPs.

4.7. OC-Reduction-Percentage AVP

The OC-Reduction-Percentage AVP (AVP code TBD8) is type of Unsigned32 and describes the percentage of the traffic that the sender is requested to reduce, compared to what it otherwise would have sent. The OC-Reduction-Percentage AVP applies to the default (loss like) 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 interpreted as 100. The value of 100 means that no traffic is expected, 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 requests to the other endpoint to apply any traffic abatement. The default value of the OC-Reduction-Percentage AVP is 0. When the OC-Reduction-Percentage AVP is not present in the overload report, the default value applies.

If an overload control endpoint comes out of the 100 percent traffic reduction as a result of the overload report timing out, the following concerns are RECOMMENDED to be applied. 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 percent reduction.

4.8. Attribute Value Pair flag rules

Attribute Name	AVP Code	Section Defined	Value Type	AVP flag rules: MUST	AVP flag rules: MUST NOT
OC-Supported-Features	TBD1	x.x	Grouped		V
OC-OLR	TBD2	x.x	Grouped		V
OC-Sequence-Number	TBD3	x.x	Time		V
OC-Validity-Duration	TBD4	x.x	Unsigned32		V
OC-Report-Type	TBD5	x.x	Enumerated		V
OC-Reduction -Percentage	TBD8	x.x	Unsigned32		V
OC-Feature-Vector	TBD6	x.x	Unsigned64		V

As described in the Diameter base protocol [RFC6733], the M-bit setting for a given AVP is relevant to an application and each

command within that application that includes the AVP.

The Diameter overload control AVPs SHOULD always be sent with the M-bit cleared when used within existing Diameter applications to avoid backward compatibility issues. Otherwise, when reused in newly defined Diameter applications, the DOC related AVPs SHOULD have the M-bit set.

5. Overload Control Operation

5.1. Overload Control Endpoints

The overload control solution can be considered as an overlay on top of an arbitrary Diameter network. The overload control information is exchanged over on a "DOIC association" established between two communication endpoints. The endpoints, namely the "reacting node" and the "reporting node" do not need to be adjacent Diameter peer nodes, nor they need to be the end-to-end Diameter nodes in a typical "client-server" deployment with multiple intermediate Diameter agent nodes in between. The overload control endpoints are the two Diameter nodes that decide to exchange overload control information between each other. How the endpoints are determined is specific to a deployment, a Diameter node role in that deployment and local configuration.

The following diagrams illustrate the concept of Diameter Overload End-Points and how they differ from the standard [RFC6733] defined client, server and agent Diameter nodes. The following is the key to the elements in the diagrams:

C Diameter client as defined in [RFC6733].

S Diameter server as defined in [RFC6733].

A Diameter agent, in either a relay or proxy mode, as defined in [RFC6733].

DEP Diameter Overload End-Point as defined in this document. In the following figures a DEP may terminate two different DOIC associations being a reporter and reactor at the same time.

Diameter Session A Diameter session as defined in [RFC6733].

DOIC Association A DOIC association exists between two Diameter Overload End-Points. One of the end-points is the overload reporter and the other is the overload reactor.

Figure 2 illustrates the most basic configuration where a client is connected directly to a server. In this case, the Diameter session and the DOIC association are both between the client and server.

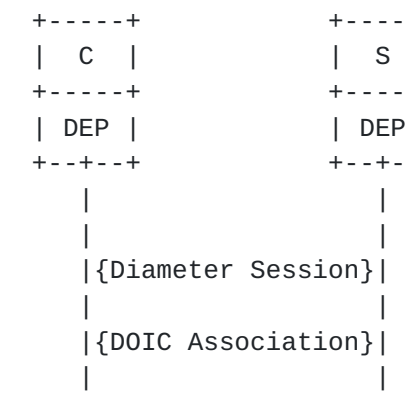

Figure 2: Basic DOIC deployment

In Figure 3 there is an agent that is not participating directly in the exchange of overload reports. As a result, the Diameter session and the DOIC association are still established between the client and the server.

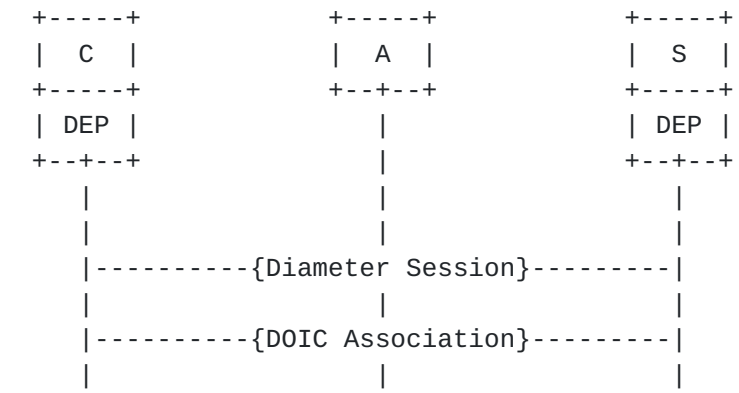

Figure 3: DOIC deployment with non participating agent

Figure 4 illustrates the case where the client does not support Diameter overload. In this case, the DOIC association is between the agent and the server. The agent handles the role of the reactor for overload reports generated by the server.

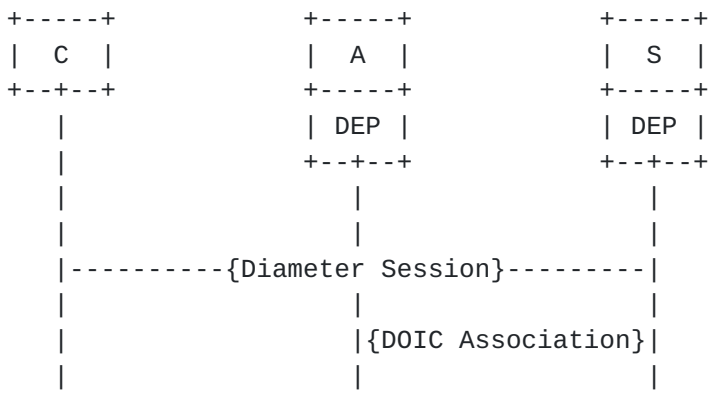

Figure 4: DOIC deployment with non-DOIC client and DOIC enabled agent

In Figure 5 there is a DOIC association between the client and the agent and a second DOIC association between the agent and the server. One use case requiring this configuration is when the agent is serving as a SFE for a set of servers.

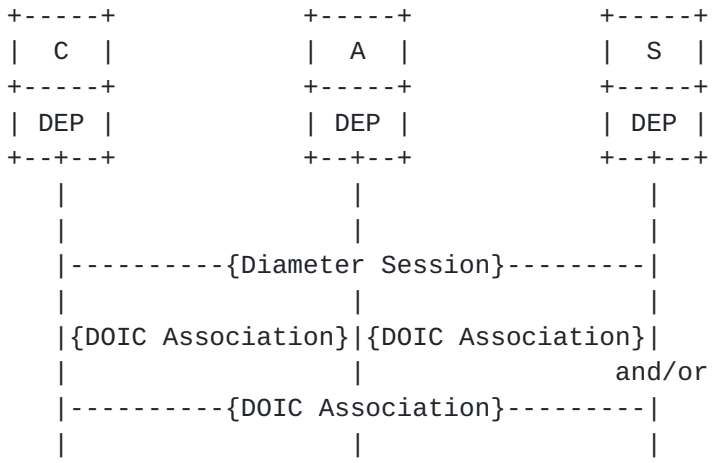

Figure 5: A deployment where all nodes support DOIC

Figure 6 illustrates a deployment where some clients support Diameter overload control and some do not. In this case the agent must support Diameter overload control for the non supporting client. It might also need to have a DOIC association with the server, as shown here, to handle overload for a server farm and/or for managing Realm overload.

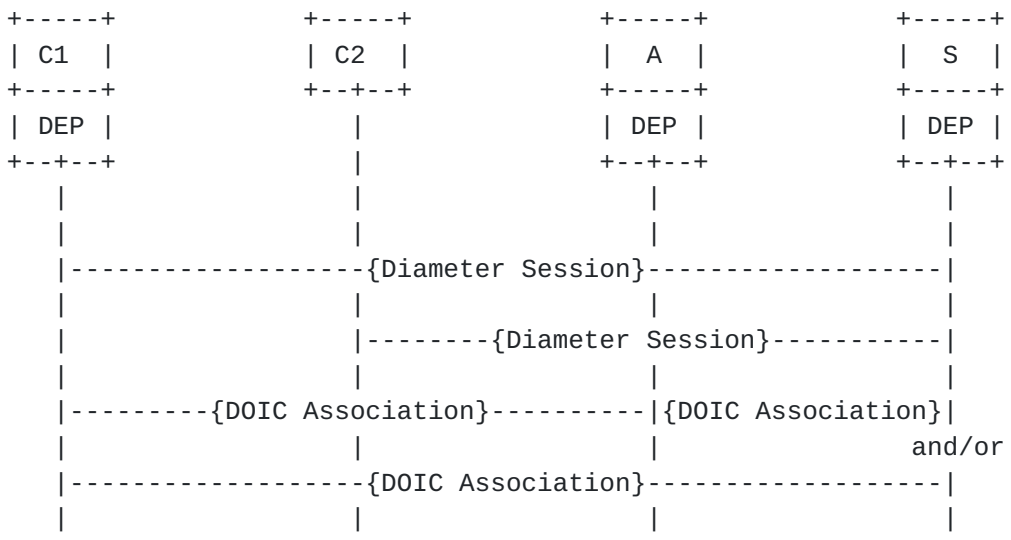

Figure 6: A deployment with DOIC and non-DOIC supporting clients

Figure 7 illustrates a deployment where some agents support Diameter overload control and others do not.

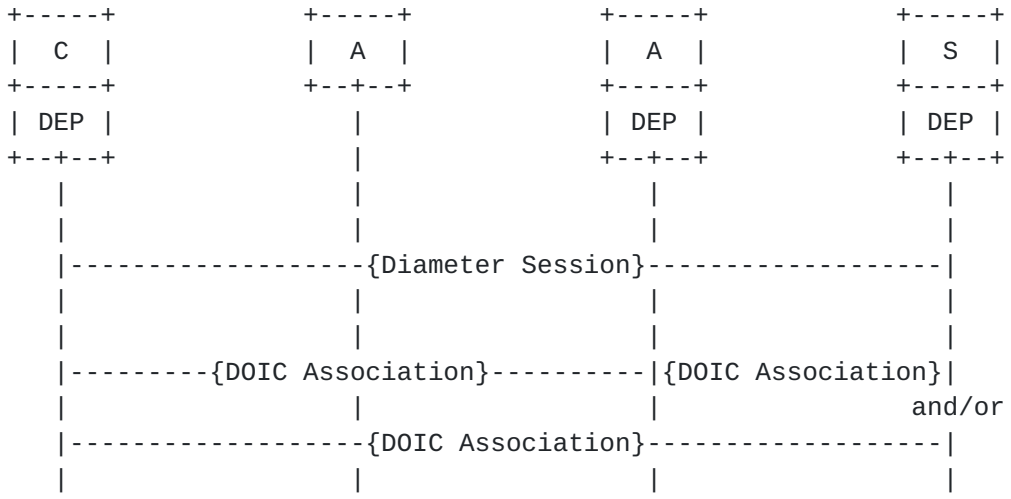

Figure 7: A deployment with DOIC and non-DOIC supporting agents

5.2. Piggybacking Principle

The overload control AVPs defined in this specification have been designed to be piggybacked on top of existing application message exchanges. This is made possible by adding overload control top level AVPs, the OC-OLR AVP and the OC-Supported-Features AVP as optional AVPs into existing commands when the corresponding Command Code Format (CCF) specification allows adding new optional AVPs (see

Section 1.3.4 of [RFC6733]).

When added to existing commands, both OC-Feature-Vector and OC-OLR AVPs SHOULD have the M-bit flag cleared to avoid backward compatibility issues.

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. In such a case, the OC-Feature-Vector and OC-OLR AVPs reused in newly defined Diameter applications SHOULD have the M-bit flag set. However, it is the responsibility of the Diameter application designers to define how overload control mechanisms works on that application.

Note that the overload control solution does not have fixed server and client roles. The endpoint 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. send by a "reporting node"). Therefore, in a typical "client-server" deployment, the "client" MAY report its overload condition to the "server" for any server initiated message exchange. An example of such is the server requesting a re-authentication from a client.

5.3. Capability Announcement

Since the overload control solution relies on the piggybacking principle for the overload reporting and the overload control endpoint are likely not adjacent peers, finding out whether the other endpoint supports the overload control or what is the common traffic abatement algorithm to apply for the traffic. The approach defined in this specification for the end-to-end capability announcement relies on the exchange of the OC-Supported-Features between the endpoints. The feature announcement solution also works when carried out on existing applications. For the newly defined application the negotiation can be more exact based on the application specification. The announced set of capabilities MUST NOT change during the life time of the Diameter session (or transaction in case of non-session maintaining applications).

5.3.1. Reacting Node Endpoint Considerations

The basic principle is that the request message initiating endpoint (i.e. the "reacting node") announces its support for the overload control mechanism by including in the request message the OC-Supported-Features AVP with those capabilities it supports and is willing to use for this Diameter session (or transaction in a case of a non-session state maintaining applications, see Section 3.1.2 for

more details on Diameter sessions). It is RECOMMENDED that the request message initiating endpoint includes the capability announcement into every request regardless it has had prior message exchanges with the give remote endpoint. In a case of a Diameter session maintaining application, sending the OC-Supported-Features AVP in every message is not really necessary after the initial capability announcement or until there is a change in supported features.

Once the endpoint that initiated the request message receives an answer message from the remote endpoint, it can detect from the received answer message whether the remote endpoint supports the overload control solution and in a case it does, what features are supported. The support for the overload control solution is based on the presence of the OC-Supported-Features AVP in the Diameter answer for existing application.

5.3.2. Reporting Node Endpoint Considerations

When a remote endpoint (i.e. a "reporting node") receives a request message, it can detect whether the request message initiating endpoint supports the overload control solution based on the presence of the OC-Supported-Features AVP. For the newly defined applications the overload control solution support can be part of the application specification. Based on the content of the OC-Supported-Features AVP the request message receiving endpoint knows what overload control functionality the other endpoint supports and then act accordingly for the subsequent answer messages it initiates. The answer message initiating endpoint MAY announce as many supported capabilities as it has (the announced set is a subject to local policy and configuration). However, at least one of the announced capabilities MUST be the same as received in the request message.

The answer message initiating endpoint MUST NOT include any overload control solution defined AVPs into its answer messages if the request message initiating endpoint has not indicated support at the beginning of the created session (or transaction in a case of non-session state maintaining applications). The same also applies if none of the announced capabilities match between the two endpoints.

5.4. Protocol Extensibility

The overload control solution can be extended, e.g. with new traffic abatement algorithms or new functionality. The new features and algorithms MUST be registered with the IANA and for the possible use with the OC-Supported-Features for announcing the support for the new features (see Section 7 for the required procedures).

It should be noted that [RFC6733] defined Grouped AVP extension mechanisms also apply. This allows, for example, defining a new feature that is mandatory to understand even when piggybacked on an existing applications. More specifically, the sub-AVPs inside the OC-OLR AVP MAY have the M-bit set. However, when overload control AVPs are piggybacked on top of an existing applications, setting M-bit in sub-AVPs is NOT RECOMMENDED.

5.5. Overload Report Processing

5.5.1. Overload Control State

Both reacting and reporting nodes maintain an overload condition state for each endpoint (a host or a realm) they communicate with and both endpoints have announced support for DOIC. See Sections 4.1 and 5.3 for discussion about how the support for DOIC is determined. The overload condition state SHOULD be able to make a difference between a realm and a specific host in that realm.

The overload condition state could include the following information (per host or realm):

- The endpoint information (Diameter identity of the realm and/or host, application identifier, etc)
- Reduction percentage
- Validity period timer
- Sequence number
- Supported/selected traffic abatement algorithm

The overload control state information SHOULD be maintained as long as the other endpoint is known to support DOIC (based on the presence of the DOIC AVPs or by a future application specification).

5.5.2. Reacting Node Considerations

Once a reacting node receives an OC-OLR AVP from a reporting node, it applies the traffic abatement based on the commonly supported algorithm with the reporting node and the current overload condition. The reacting node learns the reporting node supported abatement algorithms directly from the received answer message containing the OC-Supported-Features AVP or indirectly remembering the previously used traffic abatement algorithm with the given reporting node.

The received OC-Supported-Features AVP does not change the existing

overload condition and/or traffic abatement algorithm settings if the OC-Sequence-Number AVP contains a value that is equal to the previously received/recorded one. If the OC-Supported-Features AVP is received for the first time for the reporting node or the OC-Sequence-Number AVP value is less than the previously received/recorded one (and is outside the valid overflow window), then either the sequence number is stale (e.g. an intentional or unintentional replay) and SHOULD be silently discarded.

The OC-OLR AVP contains the necessary information of the overload condition on the reporting node. Similarly to the OC-Supported-Features's sequence numbering, the OC-OLR AVP also has the OC-Sequence-Number AVP and its handling is similar to the one in the OC-Supported-Features AVP. The reacting node MUST update its overload condition state whenever receiving the OC-OLR AVP for the first time or the OC-Sequence-Number sub-AVP indicates a change in the OC-OLR AVP.

As described in Section 4.3, the OC-OLR AVP contains the necessary information of the overload condition on the reporting node.

From the OC-Report-Type AVP contained in the OC-OLR AVP, the reacting node learns whether the overload condition report concerns a specific host (as identified by the Origin-Host AVP of the answer message containing the OC-OLR AVP) or the entire realm (as identified by the Origin-Realm AVP of the answer message containing the OC-OLR AVP). The reacting node learns the Diameter application to which the overload report applies from the Application-ID of the answer message containing the OC-OLR AVP. The reacting node MUST use this information as an input for its traffic abatement algorithm. The idea is that the reacting node applies different handling of the traffic abatement, whether sent request messages are targeted to a specific host (identified by the Diameter-Host AVP in the request) or to any host in a realm (when only the Destination-Realm AVP is present in the request). Note that future specifications MAY define new OC-Report-Type AVP values that imply different handling of the OC-OLR AVP. For example, in a form of new additional AVPs inside the Grouped OC-OLR AVP that would define report target in a finer granularity than just a host.

In the context of this specification and the default traffic abatement algorithm, the OC-Reduction-Percentage AVP value MUST be interpreted in the following way:

value == 0

Indicates explicitly the end of overload condition and the reacting node SHOULD NOT apply the traffic abatement algorithm procedures anymore for the given reporting node (or realm).

value == 100

Indicates that the reporting node (or realm) does not want to receive any traffic from the reacting node for the application the report concerns. The reacting node MUST do all measure not to send traffic to the reporting node (or realm) as long as the overload condition changes or expires.

0 < value < 100

Indicates that the reporting node urges the reacting node to reduce its traffic by a given percentage. For example if the reacting node has been sending 100 packets per second to the reporting node, then a reception of OC-Reduction-Percentage value of 10 would mean that from now on the reacting node MUST only send 90 packets per second. How the reacting node achieves the "true reduction" transactions leading to the sent request messages is up to the implementation. The reacting node MAY simply drop every 10th packet from its output queue and let the generic application logic try to recover from it.

If the OC-OLR AVP is received for the first time, the reacting node MUST create an overload condition state associated with the related realm or a specific host in the realm identified in the message carrying the OC-OLR AVP, as described in Section 5.5.1.

If the value of the OC-Sequence-Number AVP contained in the received OC-OLR AVP is equal to or less than the value stored in an existing overload condition state, the received OC-OLR AVP SHOULD be silently discarded. If the value of the OC-Sequence-Number AVP contained in the received OC-OLR AVP is greater than the value stored in an existing overload condition state or there is no previously recorded sequence number, the reacting node MUST update the overload condition state associated with the realm or the specific node is the realm.

When an overload condition state is created or updated, the reacting node MUST apply the traffic abatement requested in the OC-OLR AVP using the algorithm announced in the OC-Supported-Features AVP contained in the received answer message along with the OC-OLR AVP.

The validity duration of the overload information contained in the OC-OLR AVP is either explicitly indicated in the OC-Validity-Duration

AVP or is implicitly equals to the default value (5 seconds) if the OC-Validity-Duration AVP is absent of the OC-OLR AVP. The reacting node MUST maintain the validity duration in the overload condition state. Once the validity duration times out, the reacting node MUST assume the overload condition reported in a previous OC-OLR AVP has ended.

5.5.3. Reporting Node Considerations

A reporting node is a Diameter node inserting an OC-OLR AVP in a Diameter message in order to inform a reacting node about an overload condition and request Diameter traffic abatement.

The operation on the reporting node is rather straight forward. The reporting node learns the capabilities of the reacting node when it receives the OC-Supported-Features AVP as part of any Diameter request message. If the reporting node shares at least one common feature with the reacting node, then the DOIC can be enabled between these two endpoints. See Section 5.3 for further discussion on the capability and feature announcement between two endpoints.

When a traffic reduction is required due to an overload condition and the overload control solution is supported by the sender of the Diameter request, the reporting node MUST include an OC-Supported-Features AVP and an OC-OLR AVP in the corresponding Diameter answer. The OC-OLR AVP contains the required traffic reduction and the OC-Supported-Features AVP indicates the traffic abatement algorithm to apply. This algorithm MUST be one of the algorithms advertised by the request sender.

A reporting node MAY rely on the OC-Validity-Duration AVP values for the implicit overload condition state cleanup on the reacting node. However, it is RECOMMENDED that the reporting node always explicitly indicates the end of a overload condition.

6. Transport Considerations

In order to reduce overload control introduced additional AVP and message processing it might be desirable/beneficial to signal whether the Diameter command carries overload control information that should be of interest of an overload aware Diameter node.

Should such indication be include is not part of this specification. It has not either been concluded at what layer such possible indication should be. Obvious candidates include transport layer protocols (e.g., SCTP PPID or TCP flags) or Diameter command header flags.

7. IANA Considerations

7.1. AVP codes

New AVPs defined by this specification are listed in Section 4. All AVP codes allocated from the 'Authentication, Authorization, and Accounting (AAA) Parameters' AVP Codes registry.

7.2. New registries

Three new registries are needed under the 'Authentication, Authorization, and Accounting (AAA) Parameters' registry.

Section 4.2 defines a new "Overload Control Feature Vector" registry including the initial assignments. New values can be added into the registry using the Specification Required policy [RFC5226]. See Section 4.2 for the initial assignment in the registry.

Section 4.6 defines a new "Overload Report Type" registry with its initial assignments. New types can be added using the Specification Required policy [RFC5226].

8. Security Considerations

This mechanism gives Diameter nodes the ability to request that downstream nodes send fewer Diameter requests. Nodes do this by exchanging overload reports that directly affect 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.

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 its 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.

8.1. 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 hop-by-hop 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 occurs 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 a response. Therefore, implementations SHOULD validate that an answer containing an overload report is a properly constructed response to a pending request prior to acting on the overload report.

A similar attack involves an otherwise authorized Diameter 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 an peer that applies to a realm not handled by that peer is suspect.

An attacker might use the information in an overload report to assist in certain attacks. For example, an attacker could use information about current overload conditions to time a DoS attack for maximum effect, or use subsequent overload reports as a feedback mechanism to learn the results of a previous or ongoing attack.

8.2. Denial of Service Attacks

Diameter overload 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 tacks. 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. Therefore, Diameter nodes MUST NOT honor or forward overload reports from unauthorized or otherwise untrusted sources.

8.3. Non-Compliant Nodes

When a Diameter node sends an overload report, it cannot assume that all nodes will comply. A non-compliant node might continue to send requests with no reduction in load. Requirement 28 [RFC7068] indicates that the overload control solution cannot assume that all Diameter nodes in a network are necessarily trusted, and that malicious nodes not be allowed to take advantage of the overload control mechanism to get more than their fair share of service.

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 reject 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.

8.4. End-to End-Security Issues

The lack of end-to-end security features makes it far more difficult to establish trust in overload reports that originate 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.

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.

At the time of this writing, the DIME working group is studying requirements for adding end-to-end security [I-D.ietf-dime-e2e-sec-req] features to Diameter. These features, when they become available, 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 encourages 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.

9. Contributors

The following people contributed substantial ideas, feedback, and discussion to this document:

- Eric McMurry
- Hannes Tschofenig
- Ulrich Wiehe
- Jean-Jacques Trottin
- Maria Cruz Bartolome
- Martin Dolly
- Nirav Salot
- Susan Shishufeng

10. References

10.1. Normative References

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10.2. Informative References

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Requirements", RFC 7068, November 2013.

Appendix A. Issues left for future specifications

The base solution for the overload control does not cover all possible use cases. A number of solution aspects were intentionally left for future specification and protocol work.

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 4.1 and 7 for the required IANA steps.

A.2. Agent Overload

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

A.3. DIAMETER_TOO_BUSY clarifications

The current [RFC6733] behaviour in a case of DIAMETER_TOO_BUSY is somewhat under specified. For example, there is no information how long the specific Diameter node is willing to be unavailable. A specification updating [RFC6733] should clarify the handling of DIAMETER_TOO_BUSY from the error answer initiating Diameter node point of view and from the original request initiating Diameter node point of view. Further, the inclusion of possible additional information providing AVPs should be discussed and possible be recommended to be used.

Appendix B. Examples

B.1. Mix of Destination-Realm routed requests and Destination-Host routed requests

Diameter allows a client to optionally select the destination server of a request, even if there are agents between the client and the server. The client does this using the Destination-Host AVP. In cases where the client does not care if a specific server receives the request, it can omit Destination-Host and route the request using the Destination-Realm and Application Id, effectively letting an agent select the server.

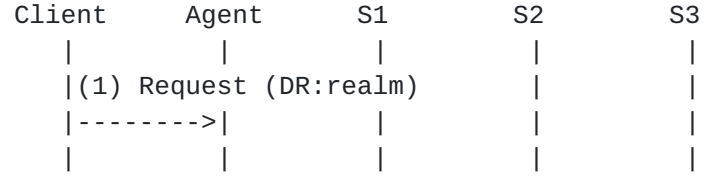
Clients commonly send mixtures of Destination-Host and Destination-Realm routed requests. For example, in an application that uses user sessions, a client typically won't care which server handles a session-initiating requests. But once the session is initiated, the client will send all subsequent requests in that session to the same server. Therefore it would send the initial request with no Destination-Host AVP. If it receives a successful answer, the client would copy the Origin-Host value from the answer message into a Destination-Host AVP in each subsequent request in the session.

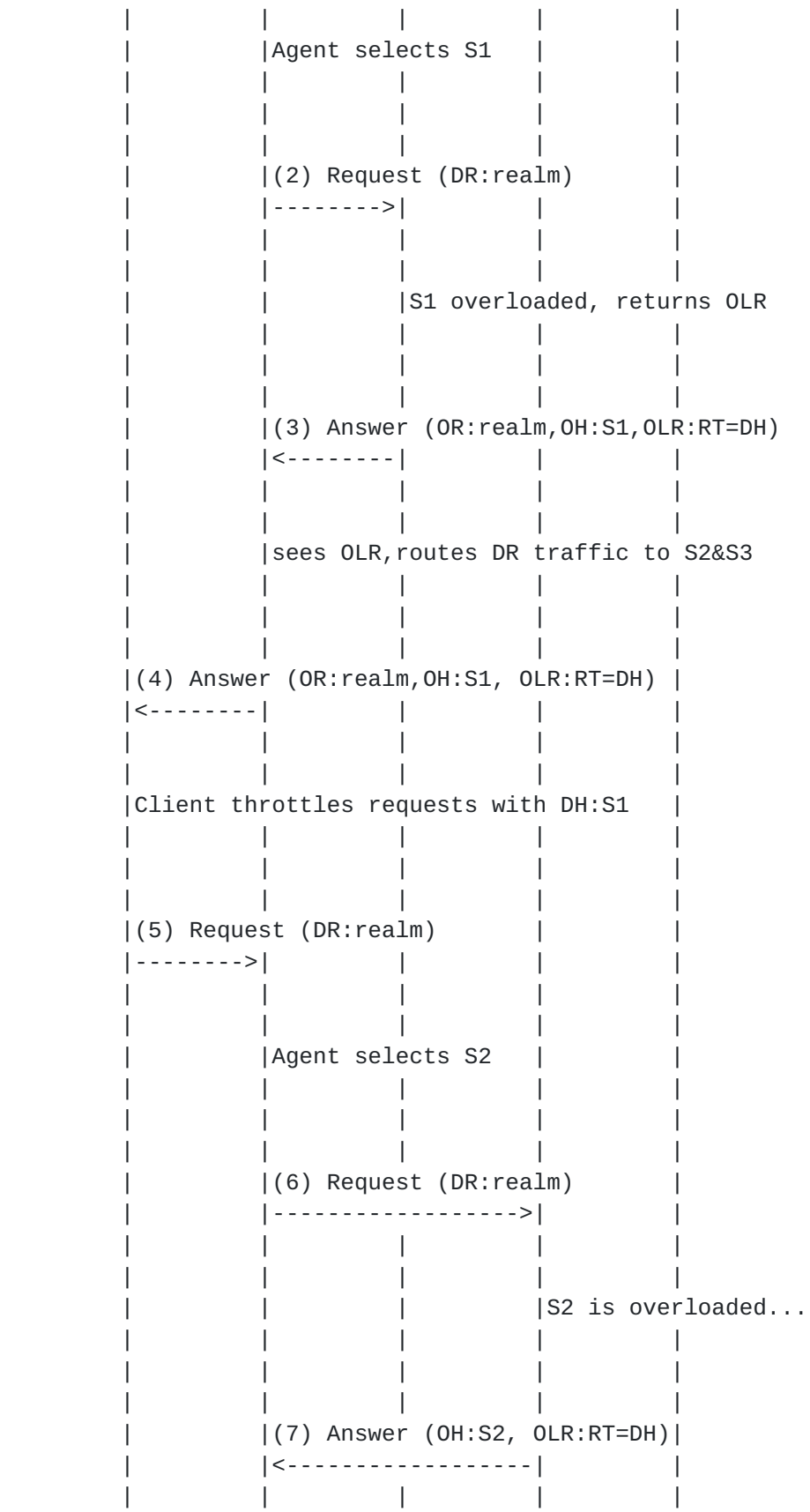
An agent has very limited options in applying overload abatement to requests that contain Destination-Host AVPs. It typically cannot route the request to a different server than the one identified in Destination-Host. It's only remaining options are to throttle such requests locally, or to send an overload report back towards the client so the client can throttle the requests. The second choice is usually more efficient, since it prevents any throttled requests from being sent in the first place, and removes the agent's need to send errors back to the client for each dropped request.

On the other hand, an agent has much more leeway to apply overload abatement for requests that do not contain Destination-Host AVPs. If the agent has multiple servers in its peer table for the given realm and application, it can route such requests to other, less overloaded servers.

If the overload severity increases, the agent may reach a point where there is not sufficient capacity across all servers to handle even realm-routed requests. In this case, the realm itself can be considered overloaded. The agent may need the client to throttle realm-routed requests in addition to Destination-Host routed requests. The overload severity may be different for each server, and the severity for the realm at is likely to be different than for any specific server. Therefore, an agent may need to forward, or originate, multiple overload reports with differing ReportType and Reduction-Percentage values.

Figure 8 illustrates such a mixed-routing scenario. In this example, the servers S1, S2, and S3 handle requests for the realm "realm". Any of the three can handle requests that are not part of a user session (i.e. routed by Destination-Realm). But once a session is established, all requests in that session must go to the same server.




Agent selects S1
(2) Request (DR:realm)
S1 overloaded, returns OLR
(3) Answer (OR:realm,OH:S1,OLR:RT=DH)
sees OLR,routes DR traffic to S2&S3
(4) Answer (OR:realm,OH:S1, OLR:RT=DH)
Client throttles requests with DH:S1
(5) Request (DR:realm)
Agent selects S2
(6) Request (DR:realm)
S2 is overloaded...
(7) Answer (OH:S2, OLR:RT=DH)

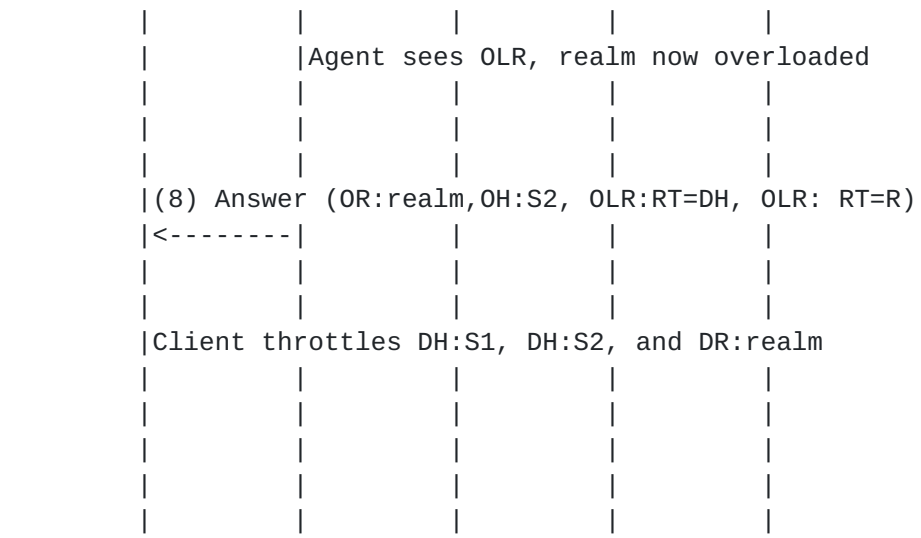


Figure 8: Mix of Destination-Host and Destination-Realm Routed Requests

1. The client sends a request with no Destination-Host AVP (that is, a Destination-Realm routed request.)

2. The agent follows local policy to select a server from its peer table. In this case, the agent selects S2 and forwards the request.

3. S1 is overloaded. It sends a answer indicating success, but also includes an overload report. Since the overload report only applies to S1, the ReportType is "Destination-Host".

4. The agent sees the overload report, and records that S1 is overloaded by the value in the Reduction-Percentage AVP. It begins diverting the indicated percentage of realm-routed traffic from S1 to S2 and S3. Since it can't divert Destination-Host routed traffic, it forwards the overload report to the client. This effectively delegates the throttling of traffic with Destination-Host:S1 to the client.

5. The client sends another Destination-Realm routed request.

6. The agent selects S2, and forwards the request.

7. It turns out that S2 is also overloaded, perhaps due to all that traffic it took over for S1. S2 returns an successful answer containing an overload report. Since this report only applies to S2, the ReportType is "Destination-Host".

8. The agent sees that S2 is also overloaded by the value in Reduction-Percentage. This value is probably different than the value from S1's report. The agent diverts the remaining traffic to S3 as best as it can, but it calculates that the remaining capacity across all three servers is no longer sufficient to handle all of the realm-routed traffic. This means the realm itself is overloaded. The realm's overload percentage is most likely different than that for either S1 or S2. The agent forward's S2's report back to the client in the Diameter answer. Additionally, the agent generates a new report for the realm of "realm", and inserts that report into the answer. The client throttles requests with Destination-Host:S1 at one rate, requests with Destination-Host:S2 at another rate, and requests with no Destination-Host AVP at yet a third rate. (Since S3 has not indicated overload, the client does not throttle requests with Destination-Host:S3.)

Authors' Addresses

Jouni Korhonen (editor)
Broadcom
Porkkalankatu 24
Helsinki FIN-00180
Finland

Email: jouni.nospam@gmail.com

Steve Donovan
Oracle
17210 Campbell Road
Dallas, Texas 75254
United States

Email: srdonovan@usdonovans.com

Ben Campbell
Oracle
17210 Campbell Road
Dallas, Texas 75254
United States

Email: ben@nostrum.com

Lionel Morand
Orange Labs
38/40 rue du General Leclerc
Issy-Les-Moulineaux Cedex 9 92794
France

Phone: +33145296257
Email: lionel.morand@orange.com