



Diameter

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Diameter 1.2
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1 Diameter Users Guide

The diameter application is a framework for building applications on top of the Diameter protocol.

1.1 Introduction

The diameter application is an implementation of the Diameter protocol as defined by RFC 3588. It supports arbitrary Diameter applications by way of a *dictionary* interface that allows messages and AVP's to be defined and input into diameter as configuration. It has support for all roles defined in the RFC: client, server and agent. This chapter provides a short overview of the application.

A Diameter node is implemented by configuring a *service* and one or more *transports* using the interface module *diameter*. The service configuration defines the Diameter applications to be supported by the node and, typically, the capabilities that it should send to remote peers at capabilities exchange upon the establishment of transport connections. A transport is configured on a service and provides protocol-specific send/receive functionality by way of a transport interface defined by diameter and implemented by a transport module. The diameter application provides two transport modules: *diameter_tcp* and *diameter_sctp* for transport over TCP (using *gen_tcp*) and SCTP (using *gen_sctp*) respectively. Other transports can be provided by any module that implements diameter's *transport interface*.

While a service typically implements a single Diameter node (as identified by an Origin-Host AVP), transports can themselves be associated with capabilities AVP's so that a single service can be used to implement more than one Diameter node.

Each Diameter application defined on a service is configured with a callback module that implements the *application interface* through which diameter communicates the connectivity of remote peers, requests peer selection for outgoing requests, and communicates the reception of incoming Diameter request and answer messages. An application using diameter implements these application callback modules to provide the functionality of the Diameter node(s) it implements.

Each Diameter application is also configured with a dictionary module that provide encode/decode functionality for outgoing/incoming Diameter messages belonging to the application. A dictionary module is generated from a *specification file* using the *diameterc* utility. Dictionaries for the RFC 3588 Diameter Common Messages, Base Accounting and Relay applications are provided with the diameter application.

1.2 Usage

To be written.

1.3 Examples

Example code can be found in the diameter application's `examples` subdirectory.

1.4 Standards Compliance

Known points of questionable or non-compliance.

1.4.1 RFC 3588

- The End-to-End Security framework (section 2.9) isn't implemented since it is largely unspecified. The document that was to describe it (reference [AAACMS]) was abandoned in an uncompleted state several years ago and the current draft RFC deprecates the framework, including the P Flag in the AVP header.
- There is no TLS support over SCTP. RFC 3588 requires that a Diameter server support TLS but in practise this seems to mean TLS over SCTP since there are limitations with running over SCTP: see RFC 6083 (DTLS over SCTP), which is a response to RFC 3436 (TLS over SCTP). The current RFC 3588 draft acknowledges this by equating TLS with TLS/TCP and DTLS/SCTP but we do not yet support DTLS.
- There is no explicit support for peer discovery (section 5.2). It can possibly be implemented on top of diameter as is but this is probably something that diameter should do. The current draft deprecates portions of the original RFC's mechanisms however.
- The peer state machine's election process (section 5.6.4) isn't implemented as specified since it assumes knowledge of a peer's Origin-Host before sending it a CER. (The identity becoming known upon reception of CEA.) The possibility of configuring the peer's Origin-Host could be added, along with handling of the case that it sends something else, but for many applications this will just be unnecessary configuration of a value that it has no control over.

1.4.2 RFC 3539

RFC 3539 is more difficult to comply to since it discusses problems as much as it requires functionality but all the MUST's are covered, the watchdog state machine being the primary one. Of the optional functionality, load balancing is left to the diameter user (since it's the one deciding who to send to) and there is no Congestion Manager.

2 Reference Manual

The Diameter application is a framework for building applications on top of the Diameter protocol.

diameter

Erlang module

This module provides the interface with which a user can implement a Diameter node that sends and receives messages using the Diameter protocol as defined in RFC 3588.

Basic usage consists of creating a representation of a locally implemented Diameter node and its capabilities with *start_service/2*, adding transport capability using *add_transport/2* and sending Diameter requests and receiving Diameter answers with *call/4*. Incoming Diameter requests are communicated as callbacks to a *diameter_app(3)* callback modules as specified in the service configuration.

Beware the difference between *diameter* (not capitalised) and *Diameter* (capitalised). The former refers to the Erlang application named diameter whose main api is defined here, the latter to Diameter protocol in the sense of RFC 3588.

The diameter application must be started before calling most functions in this module.

DATA TYPES

Address()
DiameterIdentity()
Grouped()
OctetString()
Time()
Unsigned32()
UTF8String()

Types corresponding to RFC 3588 AVP Data Formats. Defined in *diameter_dict(4)*.

application_alias() = term()

A name identifying a Diameter application in service configuration. Passed to *call/4* when sending requests defined by the application.

application_module() = Mod | [Mod | ExtraArgs] | #diameter_callback{}

```
Mod = atom()
ExtraArgs = list()
```

A module implementing the callback interface defined in *diameter_app(3)*, along with any extra arguments to be appended to those documented for the interface. Note that extra arguments specific to an outgoing request can be specified to *call/4*, in which case those are are appended to any module-specific extra arguments.

Specifying a #diameter_callback{ } record allows individual functions to be configured in place of the usual *diameter_app(3)* callbacks. See that module for details.

application_opt()

Options defining a Diameter application. Has one the following types.

{alias, *application_alias()*}

An unique identifier for the application in the scope of the service. Defaults to the value of the dictionary option if unspecified.

```
{dictionary, atom() }
```

The name of an encode/decode module for the Diameter messages defined by the application. These modules are generated from a specification file whose format is documented in *diameter_dict(4)*.

```
{module, application_module() }
```

The callback module with which messages of the Diameter application are handled. See *diameter_app(3)* for the required interface and semantics.

```
{state, term() }
```

The initial callback state. The prevailing state is passed to some *diameter_app(3)* callbacks, which can then return a new state. Defaults to the value of the *alias* option if unspecified.

```
{call_mutates_state, true|false }
```

Specifies whether or not the *pick_peer/4* application callback can modify the application state, Defaults to *false* if unspecified.

Note:

pick_peer callbacks are serialized when these are allowed to modify state, which is a potential performance bottleneck. A simple Diameter client may suffer no ill effects from using mutable state but a server or agent that responds to incoming request should probably avoid it.

```
{answer_errors, callback|report|discard }
```

Determines the manner in which incoming answer messages containing decode errors are handled. If *callback* then errors result in a *handle_answer/4* callback in the same fashion as for *handle_request/3*, with errors communicated in the *errors* field of the *#diameter_packet{ }* record passed to the callback. If *report* then an answer containing errors is discarded without a callback and a warning report is written to the log. If *discard* then an answer containing errors is silently discarded without a callback. In both the *report* and *discard* cases the return value for the *call/4* invocation in question is as if a callback had taken place and returned *{error, failure}*.

Defaults to *report* if unspecified.

call_opt()

Options available to *call/4* when sending an outgoing Diameter request. Has one of the following types.

```
{extra, list() }
```

Extra arguments to append to callbacks to the callback module in question. These are appended to any extra arguments configured on the callback itself. Multiple options append to the argument list.

```
{filter, peer_filter() }
```

A filter to apply to the list of available peers before passing them to the *pick_peer/4* callback for the application in question. Multiple options are equivalent a single *all* filter on the corresponding list of filters. Defaults to *none*.

```
{timeout, Unsigned32() }
```

The number of milliseconds after which the request should timeout. Defaults to 5000.

detach

Causes *call/4* to return *ok* as soon as the request in question has been encoded instead of waiting for and returning the result from a subsequent *handle_answer/4* or *handle_error/4* callback.

An invalid option will cause *call/4* to fail.

capability()

AVP values sent in outgoing CER or CEA messages during capabilities exchange. Can be configured both on a service and a transport, values specified on the latter taking precedence over any specified on the former. Has one of the following types.

```
{ 'Origin-Host', DiameterIdentity() }
{ 'Origin-Realm', DiameterIdentity() }
{ 'Host-IP-Address', [Address()] }
```

An address list is available to the start function of a *transport module*, which can return a new list for use in the subsequent CER or CEA. Host-IP-Address need not be specified if the transport start function returns an address list.

```
{ 'Vendor-Id', Unsigned32() }
{ 'Product-Name', UTF8String() }
{ 'Origin-State-Id', Unsigned32() }
```

Origin-State-Id is optional but will be included in outgoing messages sent by diameter itself: CER/CEA, DWR/DWA and DPR/DPA. Setting a value of 0 (zero) is equivalent to not setting a value as documented in RFC 3588. The function *origin_state_id/0* can be used as to retrieve a value that is computed when the diameter application is started.

```
{ 'Supported-Vendor-Id', [Unsigned32()] }
{ 'Auth-Application-Id', [Unsigned32()] }
{ 'Inband-Security-Id', [Unsigned32()] }
```

Inband-Security-Id defaults to the empty list, which is equivalent to a list containing only 0 (= NO_INBAND_SECURITY). If 1 (= TLS) is specified then TLS is selected if the CER/CEA received from the peer offers it.

```
{ 'Acct-Application-Id', [Unsigned32()] }
{ 'Vendor-Specific-Application-Id', [Grouped()] }
{ 'Firmware-Revision', Unsigned32() }
```

Note that each tuple communicates one or more AVP values. It is an error to specify duplicate tuples.

evaluable() = {M,F,A} | fun() | [evaluable() | A]

An expression that can be evaluated as a function in the following sense.

```
eval([M,F,A] | T) ->
  apply(M, F, T ++ A);
eval([F|A] | T) ->
  eval([F | T ++ A]);
eval([F|A]) ->
  apply(F, A);
eval(F) ->
  eval([F]).
```

Applying an *evaluable()* E to an argument list A is meant in the sense of `eval([E|A])`.

Warning:

Beware of using fun expressions of the form `fun Name/Arity` (not `fun Mod:Name/Arity`) in situations in which the fun is not short-lived and code is to be upgraded at runtime since any processes retaining such a fun will have a reference to old code.

`peer_filter() = term()`

A filter passed to *call/4* in order to select candidate peers for a *pick_peer/4* callback. Has one of the following types.

`none`

Matches any peer. This is a convenience that provides a filter equivalent to no filter at all.

`host`

Matches only those peers whose `Origin-Host` has the same value as `Destination-Host` in the outgoing request in question, or any peer if the request does not contain a `Destination-Host` AVP.

`realm`

Matches only those peers whose `Origin-Realm` has the same value as `Destination-Realm` in the outgoing request in question, or any peer if the request does not contain a `Destination-Realm` AVP.

`{host, any|DiameterIdentity() }`

Matches only those peers whose `Origin-Host` has the specified value, or all peers if the atom `any`.

`{realm, any|DiameterIdentity() }`

Matches only those peers whose `Origin-Realm` has the specified value, or all peers if the atom `any`.

`{eval, evaluable() }`

Matches only those peers for which the specified *evaluable()* returns `true` on the connection's `diameter_caps` record. Any other return value or exception is equivalent to `false`.

`{neg, peer_filter() }`

Matches only those peers not matched by the specified filter.

`{all, [peer_filter()] }`

Matches only those peers matched by each filter in the specified list.

`{any, [peer_filter()] }`

Matches only those peers matched by at least one filter in the specified list.

An invalid filter is equivalent to `{any, [] }`, a filter that matches no peer.

Note:

The `host` and `realm` filters examine the outgoing request as passed to *call/4*, assuming that this is a record- or list-valued *diameter_app:message()*, and that the message contains at most one of each AVP. If this is not the case then the `{host|realm, DiameterIdentity() }` filters must be used to achieve the desired result. An empty *DiameterIdentity()* (which should not be typical) matches all hosts/ realms for the purposes of filtering.

Warning:

A `host` filter is not typically desirable when setting `Destination-Host` since it will remove peer agents from the candidates list.

```
service_event() = #diameter_event{}
```

An event message sent to processes that have subscribed to these using *subscribe/1*.

The `info` field of the event record can have one of the following types.

```
{up, Ref, Peer, Config, Pkt}
{up, Ref, Peer, Config}
{down, Ref, Peer, Config}
```

```
Ref      =
Peer     =
Config = {connect|listen, []}
Pkt      = #diameter_packet{}
```

The RFC 3539 watchdog state machine has transitioned into (up) or out of (down) the OKAY state. If a `#diameter_packet{}` record is present in an up event then there has been a capabilities exchange on a newly established transport connection and the record contains the received CER or CEA. Otherwise a connection has reestablished without the loss or connectivity.

Note that a single up/down event for a given peer corresponds to one *peer_up/peer_down* callback for each of the Diameter applications negotiated during capabilities exchange. That is, the event communicates connectivity with the peer as a whole while the callbacks communicate connectivity with respect to individual Diameter applications.

```
{reconnect, Ref, Opts}
```

```
Ref  =
Opts = []
```

A connecting transport is attempting to establish/reestablish a transport connection with a peer following *reconnect_timer* or *watchdog_timer* expiry.

```
{closed, Ref, Reason, Config}
```

```
Ref =
Config = {connect|listen, []}
```

Capabilities exchange has failed. Reason can have one of the following types.

```
{'CER', Result, Caps, Pkt}
```

```
Result = ResultCode | {capabilities_cb, CB, ResultCode|discard}
Caps = #diameter_caps{}
Pkt = #diameter_packet{}
ResultCode = integer()
CB =
```

An incoming CER has been answered with the indicated result code or discarded. Caps contains pairs of values for the the local node and remote peer. Pkt contains the CER in question. In the case of rejection by a capabilities callback, the tuple contains the rejecting callback.

```
{'CER', Caps, {ResultCode, Pkt}}
```

```
ResultCode = integer()  
Caps = #diameter_caps{}  
Pkt = #diameter_packet{}
```

An incoming CER contained errors and has been answered with the indicated result code. Caps contains only values for the the local node. Pkt contains the CER in question.

```
{'CEA', Result, Caps, Pkt}
```

```
Result = integer() | atom() | {capabilities_cb, CB, ResultCode|discard}  
Caps = #diameter_caps{}  
Pkt = #diameter_packet{}  
ResultCode = integer()
```

An incoming CEA has been rejected for the indicated reason. An integer-valued Result indicates the result code sent by the peer. Caps contains pairs of values for the the local node and remote peer. Pkt contains the CEA in question. In the case of rejection by a capabilities callback, the tuple contains the rejecting callback.

```
{'CEA', Caps, Pkt}
```

```
Caps = #diameter_caps{}  
Pkt = #diameter_packet{}
```

An incoming CEA contained errors and has been rejected. Caps contains only values for the the local node. Pkt contains the CEA in question.

```
{watchdog, Ref, PeerRef, {From, To}, Config}
```

```
Ref =  
PeerRef =  
From, To = initial | okay | suspect | down | reopen  
Config = {connect|listen, [transport_opt()]}
```

An RFC 3539 watchdog state machine has changed state.

For forward compatibility, a subscriber should be prepared to receive info fields of forms other than the above.

```
service_name() = term()
```

The name of a service as passed to *start_service/2* and with which the service is identified. There can be at most one service with a given name on a given node. Note that *erlang:make_ref/0* can be used to generate a service name that is somewhat unique.

```
service_opt()
```

An option passed to *start_service/2*. Can be any *capability()* as well as the following.

```
{application, [application_opt()]}
```

Defines a Diameter application supported by the service.

A service must configure one *application* for each Diameter application it intends to support. For an outgoing Diameter request, the relevant *application_alias()* is passed to *call/4*, while for an incoming request

the application identifier in the message header determines the application, the identifier being specified in the application's *dictionary* file.

`transport_opt()`

An option passed to *add_transport/2*. Has one of the following types.

```
{transport_module, atom() }
```

A module implementing a transport process as defined in *diameter_transport(3)*. Defaults to *diameter_tcp* if unspecified.

Multiple *transport_module* and *transport_config* options are allowed. The order of these is significant in this case (and only in this case), a *transport_module* being paired with the first *transport_config* following it in the options list, or the default value for trailing modules. Transport starts will be attempted with each of the modules in order until one establishes a connection within the corresponding timeout (see below) or all fail.

```
{transport_config, term()}
{transport_config, term(), Unsigned32() }
```

A term passed as the third argument to the *start/3* function of the relevant *transport_module* in order to start a transport process. Defaults to the empty list if unspecified.

The 3-tuple form additionally specifies an interval, in milliseconds, after which a started transport process should be terminated if it has not yet established a connection. For example, the following options on a connecting transport request a connection with one peer over SCTP or another (typically the same) over TCP.

```
{transport_module, diameter_sctp}
{transport_config, SctpOpts, 5000}
{transport_module, diameter_tcp}
{transport_config, TcpOpts}
```

To listen on both SCTP and TCP, define one transport for each.

```
{applications, [application_alias()] }
```

The list of Diameter applications to which the transport should be restricted. Defaults to all applications configured on the service in question. Applications not configured on the service in question are ignored.

```
{capabilities, [capability()] }
```

AVP's used to construct outgoing CER/CEA messages. Values take precedence over any specified on the service in question.

Specifying a capability as a transport option may be particularly appropriate for Inband-Security-Id, in case TLS is desired over TCP as implemented by *diameter_tcp(3)*.

```
{capabilities_cb, evaluable() }
```

A callback invoked upon reception of CER/CEA during capabilities exchange in order to ask whether or not the connection should be accepted. Applied to the relevant *transport_ref()* and the *#diameter_caps{ }* record of the connection. Returning *ok* accepts the connection. Returning *integer()* causes an incoming CER to be answered with the specified Result-Code. Returning *discard* causes an incoming CER to be discarded. Returning *unknown* is equivalent to returning 3010, *DIAMETER_UNKNOWN_PEER*. Returning anything but *ok* or a 2xxx series result code causes the transport connection to be broken.

Multiple *capabilities_cb* options can be specified, in which case the corresponding callbacks are applied until either all return *ok* or one does not.

```
{watchdog_timer, TwInit}
```

```
TwInit =  
    | {M,F,A}
```

The RFC 3539 watchdog timer. An integer value is interpreted as the RFC's TwInit in milliseconds, a jitter of ± 2 seconds being added at each rearming of the timer to compute the RFC's Tw. An MFA is expected to return the RFC's Tw directly, with jitter applied, allowing the jitter calculation to be performed by the callback.

An integer value must be at least 6000 as required by RFC 3539. Defaults to 30000 if unspecified.

```
{reconnect_timer, Tc}
```

```
Tc =
```

For a connecting transport, the RFC 3588 Tc timer, in milliseconds. Note that this timer determines the frequency with which a transport will attempt to establish a connection with its peer only *before* an initial connection is established: once there is an initial connection it's watchdog_timer that determines the frequency of reconnection attempts, as required by RFC 3539.

For a listening transport, the timer specifies the time after which a previously connected peer will be forgotten: a connection after this time is regarded as an initial connection rather than a reestablishment, causing the RFC 3539 state machine to pass to state OPEN rather than REOPEN. Note that these semantics are not governed by the RFC and that a listening transport's reconnect_timer should be greater than its peer's Tw plus jitter.

Defaults to 30000 for a connecting transport and 60000 for a listening transport.

Unrecognized options are silently ignored but are returned unmodified by *service_info/2* and can be referred to in predicate functions passed to *remove_transport/2*.

```
transport_ref() = reference()
```

An reference returned by *add_transport/2* that identifies the configuration.

Exports

```
add_transport(SvcName, {connect|listen, [Opt]}) -> {ok, Ref} | {error, Reason}
```

Types:

```
SvcName = service_name()  
Opt = transport_opt()  
Ref = transport_ref()  
Reason = term()
```

Add transport capability to a service.

The service will start transport processes as required in order to establish a connection with the peer, either by connecting to the peer (*connect*) or by accepting incoming connection requests (*listen*). A connecting transport establishes transport connections with at most one peer, an listening transport potentially with many.

The diameter application takes responsibility for exchanging CER/CEA with the peer. Upon successful completion of capabilities exchange the service calls each relevant application module's *peer_up/3* callback after which the caller can exchange Diameter messages with the peer over the transport. In addition to CER/CEA, the service takes responsibility for the handling of DWR/DWA and required by RFC 3539, as well as for DPR/DPA.

The returned reference uniquely identifies the transport within the scope of the service. Note that the function returns before a transport connection has been established.

Note:

It is not an error to add a transport to a service that has not yet been configured: a service can be started after configuring its transports.

```
call(SvcName, App, Request, [Opt]) -> Answer | ok | {error, Reason}
```

Types:

```
SvcName = service_name()
App = application_alias()
Request = diameter_app:message()
Answer = term()
Opt = call_opt()
```

Send a Diameter request message.

App specifies the Diameter application in which the request is defined and callbacks to the corresponding callback module will follow as described below and in *diameter_app(3)*. Unless the `detach` option is specified, the call returns either when an answer message is received from the peer or an error occurs. In the answer case, the return value is as returned by a *handle_answer/4* callback. In the error case, whether or not the error is returned directly by diameter or from a *handle_error/4* callback depends on whether or not the outgoing request is successfully encoded for transmission to the peer, the cases being documented below.

If there are no suitable peers, or if *pick_peer/4* rejects them by returning `false`, then `{error, no_connection}` is returned. Otherwise *pick_peer/4* is followed by a *prepare_request/3* callback, the message is encoded and then sent.

There are several error cases which may prevent an answer from being received and passed to a *handle_answer/4* callback:

- If the initial encode of the outgoing request fails, then the request process fails and `{error, encode}` is returned.
- If the request is successfully encoded and sent but the answer times out then a *handle_error/4* callback takes place with `Reason = timeout`.
- If the request is successfully encoded and sent but the service in question is stopped before an answer is received then a *handle_error/4* callback takes place with `Reason = cancel`.
- If the transport connection with the peer goes down after the request has been sent but before an answer has been received then an attempt is made to resend the request to an alternate peer. If no such peer is available, or if the subsequent *pick_peer/4* callback rejects the candidates, then a *handle_error/4* callback takes place with `Reason = failover`. If a peer is selected then a *prepare_retransmit/3* callback takes place, after which the semantics are the same as following an initial *prepare_request/3* callback.
- If an encode error takes place during retransmission then the request process fails and `{error, failure}` is returned.
- If an application callback made in processing the request fails (*pick_peer*, *prepare_request*, *prepare_retransmit*, *handle_answer* or *handle_error*) then either `{error, encode}` or `{error, failure}` is returned depending on whether or not there has been an attempt to send the request over the transport.

Note that `{error, encode}` is the only return value which guarantees that the request has *not* been sent over the transport connection.

origin_state_id() -> Unsigned32()

Return a reasonable value for use as Origin-State-Id in outgoing messages.

The value returned is the number of seconds since 19680120T031408Z, the first value that can be encoded as a Diameter *Time*(), at the time the diameter application was started.

remove_transport(SvcName, Pred) -> ok

Types:

```
SvcName = service_name()
Pred = Fun | MFA | transport_ref() | list() | true | false
Fun = fun((transport_ref(), connect|listen, list()) -> boolean())
    | fun((transport_ref(), list()) -> boolean())
    | fun((list()) -> boolean())
MFA = {atom(), atom(), list()}
```

Remove previously added transports.

Pred determines which transports to remove. An arity-3-valued Pred removes all transports for which Pred(Ref, Type, Opts) returns true, where Type and Opts are as passed to *add_transport/2* and Ref is as returned by it. The remaining forms are equivalent to an arity-3 fun as follows.

```
Pred = fun(transport_ref(), list()): fun(Ref, _, Opts) -> Pred(Ref, Opts) end
Pred = fun(list()): fun(_, _, Opts) -> Pred(Opts) end
Pred = transport_ref(): fun(Ref, _, _) -> Pred == Ref end
Pred = list(): fun(_, _, Opts) -> [] == Pred -- Opts end
Pred = true: fun(_, _, _) -> true end
Pred = false: fun(_, _, _) -> false end
Pred = {M,F,A}: fun(Ref, Type, Opts) -> apply(M, F, [Ref, Type, Opts | A]) end
```

Removing a transport causes all associated transport connections to be broken. A DPR message with Disconnect-Cause DO_NOT_WANT_TO_TALK_TO_YOU will be sent to each connected peer before disassociating the transport configuration from the service and terminating the transport upon reception of DPA or timeout.

service_info(SvcName, Info) -> term()

Types:

```
SvcName = service_name()
Info = Item | [Info]
Item = atom()
```

Return information about a started service. Item can be one of the following.


```
'Origin-Host'
'Origin-Realm'
'Vendor-Id'
'Product-Name'
'Origin-State-Id'
'Host-IP-Address'
'Supported-Vendor'
'Auth-Application-Id'
'Inband-Security-Id'
'Acct-Application-Id'
'Vendor-Specific-Application-Id'
'Firmware-Revision'
```

Return a capability value as configured with *start_service/2*.

applications

Return the list of applications as configured with *start_service/2*.

capabilities

Return a tagged list of all capabilities values as configured with *start_service/2*.

transport

Return a list containing one entry for each of the service's transport as configured with *add_transport/2*. Each entry is a tagged list containing both configuration and information about established peer connections. An example return value with for a client service with Origin-Host "client.example.com" configured with a single transport connected to "server.example.com" might look as follows.

```
[[{ref,#Ref<0.0.0.93>},
  {type,connect},
  {options,[{transport_module,diameter_tcp},
    {transport_config,[{ip,{127,0,0,1}},
      {raddr,{127,0,0,1}},
      {rport,3868},
      {reuseaddr,true}]}]}],
  {watchdog,{<0.66.0>,{1346,171491,996448},okay}},
  {peer,{<0.67.0>,{1346,171491,999906}}},
  {apps,[{0,common}]},
  {caps,[{origin_host,{"client.example.com","server.example.com"}},
    {origin_realm,{"example.com","example.com"}},
    {host_ip_address,[{127,0,0,1},{127,0,0,1}]},
    {vendor_id,{0,193}},
    {product_name,{"Client","Server"}},
    {origin_state_id,[[],[]]},
    {supported_vendor_id,[[],[]]},
    {auth_application_id,[{0},{0}]},
    {inband_security_id,[[],[0]}},
    {acct_application_id,[[],[]]},
    {vendor_specific_application_id,[[],[]]},
    {firmware_revision,[[],[]]},
    {avp,[[],[]]}]},
  {port,[{owner,<0.69.0>},
    {module,diameter_tcp},
    {socket,[{127,0,0,1},48758]},
    {peer,[{127,0,0,1},3868]},
    {statistics,[{recv_oct,656},
      {recv_cnt,6},
      {recv_max,148},
      {recv_avg,109},
```

```

        {recv_dvi,19},
        {send_oct,836},
        {send_cnt,6},
        {send_max,184},
        {send_avg,139},
        {send_pend,0}]]]],
{statistics,[{{0,258,0},recv},3},
             {{0,258,1},send},3},
             {{0,257,0},recv},1},
             {{0,257,1},send},1},
             {{0,258,0},recv,{ 'Result-Code',2001}},3},
             {{0,280,1},recv},2},
             {{0,280,0},send},2}]]]]

```

Here `ref` is a `transport_ref()` and options the corresponding `transport_opt()` list passed to `add_transport/2`. The `watchdog` entry shows the state of a connection's RFC 3539 watchdog state machine. The `peer` entry identifies the `diameter_app:peer_ref()` for which there will have been `peer_up` callbacks for the Diameter applications identified by the `apps` entry, common being the `application_alias()`. The `caps` entry identifies the capabilities sent by the local node and received from the peer during capabilities exchange. The `port` entry displays socket-level information about the transport connection. The `statistics` entry presents Diameter-level counters, an entry like `{{0,280,1},recv},2` saying that the client has received 2 DWR messages: `{0,280,1} = {Application_Id, Command_Code, R_Flag}`.

Note that `watchdog`, `peer`, `apps`, `caps` and `port` entries depend on connectivity with the peer and may not be present. Note also that the `statistics` entry presents values accumulated during the lifetime of the transport configuration.

A listening transport presents its information slightly differently since there may be multiple accepted connections for the same `transport_ref()`. The transport info returned by a server with a single client connection might look as follows.

```

[[{ref,#Ref<0.0.0.61>},
 {type,listen},
 {options,[{transport_module,diameter_tcp},
            {transport_config,[{reuseaddr,true},
                               {ip,{127,0,0,1}},
                               {port,3868}]]}],
 {accept,[{watchdog,{<0.56.0>,{1346,171481,226895},okay}},
           {peer,{<0.58.0>,{1346,171491,999511}}},
           {apps,[{0,common}]},
           {caps,[{origin_host,{"server.example.com","client.example.com"}},
                  {origin_realm,{"example.com","example.com"}},
                  {host_ip_address,[{127,0,0,1},{127,0,0,1}]},
                  {vendor_id,{193,0}},
                  {product_name,{"Server","Client"}},
                  {origin_state_id,[[],[]]},
                  {supported_vendor_id,[[],[]]},
                  {auth_application_id,[{0},{0}]},
                  {inband_security_id,[[],[]]},
                  {acct_application_id,[[],[]]},
                  {vendor_specific_application_id,[[],[]]},
                  {firmware_revision,[[],[]]},
                  {avp,[[],[]]}]},
           {port,[{owner,<0.62.0>},
                  {module,diameter_tcp},
                  {socket,[{127,0,0,1},3868]},
                  {peer,[{127,0,0,1},48758]},
                  {statistics,[{recv_oct,1576},
                              {recv_cnt,16},
                              {recv_max,184},

```

```

                                {recv_avg,98},
                                {recv_dvi,26},
                                {send_oct,1396},
                                {send_cnt,16},
                                {send_max,148},
                                {send_avg,87},
                                {send_pend,0}}]]],
    [{watchdog,<0.72.0>,{1346,171491,998404},initial}}]],
{statistics,[{{0,280,0},recv},7},
              {{0,280,1},send},7},
              {{0,258,0},send,{ 'Result-Code',2001}},3},
              {{0,258,1},recv},3},
              {{0,258,0},send},3},
              {{0,280,1},recv},5},
              {{0,280,0},send},5},
              {{0,257,1},recv},1},
              {{0,257,0},send},1}}]]]

```

The information presented here is as in the connect case except that the client connections are grouped under an accept tuple.

connections

Return a list containing one entry for every established transport connection whose watchdog state machine is not in the down state. This is a flat view of transport info which lists only active connections and for which Diameter-level statistics are accumulated only for the lifetime of the transport connection. A return value for the server above might look as follows.

```

[[{ref,#Ref<0.0.0.61>},
  {type,accept},
  {options,[{transport_module,diameter_tcp},
            {transport_config,[{reuseaddr,true},
                                {ip,{127,0,0,1}},
                                {port,3868}]}]},
  {watchdog,<0.56.0>,{1346,171481,226895},okay}},
  {peer,<0.58.0>,{1346,171491,999511}}],
  {apps,[{0,common}]},
  {caps,[{origin_host,"server.example.com","client.example.com"}},
        {origin_realm,{"example.com","example.com"}},
        {host_ip_address,[{127,0,0,1},{127,0,0,1}]},
        {vendor_id,{193,0}},
        {product_name,{"Server","Client"}},
        {origin_state_id,[[],[]]},
        {supported_vendor_id,[[],[]]},
        {auth_application_id,[{0},{0}]},
        {inband_security_id,[[],[]]},
        {acct_application_id,[[],[]]},
        {vendor_specific_application_id,[[],[]]},
        {firmware_revision,[[],[]]},
        {avp,[[],[]]}]},
  {port,[{owner,<0.62.0>},
        {module,diameter_tcp},
        {socket,[{127,0,0,1},3868]},
        {peer,[{127,0,0,1},48758]},
        {statistics,[{recv_oct,10124},
                      {recv_cnt,132},
                      {recv_max,184},
                      {recv_avg,76},
                      {recv_dvi,9},
                      {send_oct,10016},
                      {send_cnt,132},
                      {send_max,148},

```

```
        {send_avg,75},
        {send_pend,0}]]]],
{statistics,[{{{0,280,0},recv},62},
              {{{0,280,1},send},62},
              {{{0,258,0},send},{'Result-Code',2001}},3},
              {{{0,258,1},recv},3},
              {{{0,258,0},send},3},
              {{{0,280,1},recv},66},
              {{{0,280,0},send},66},
              {{{0,257,1},recv},1},
              {{{0,257,0},send},1}]]]]]
```

Note that there may be multiple entries with the same `ref`, in contrast to `transport` info.

`statistics`

Return a `{{Counter, Ref}, non_neg_integer()}` list of counter values. `Ref` can be either a `transport_ref()` or a `diameter_app:peer_ref()`. Entries for the latter are folded into corresponding entries for the former as peer connections go down. Entries for both are removed at `remove_transport/2`. The Diameter-level statistics returned by `transport` and `connections` info are based upon these entries.

Requesting info for an unknown service causes `undefined` to be returned. Requesting a list of items causes a tagged list to be returned.

`services()` -> [`SvcName`]

Types:

`SvcName` = `service_name()`

Return the list of started services.

`session_id(Ident)` -> `OctetString()`

Types:

`Ident` = `DiameterIdentity()`

Return a value for a Session-Id AVP.

The value has the form required by section 8.8 of RFC 3588. `Ident` should be the Origin-Host of the peer from which the message containing the returned value will be sent.

`start()` -> `ok` | `{error, Reason}`

Start the diameter application.

The diameter application must be started before starting a service. In a production system this is typically accomplished by a boot file, not by calling `start/0` explicitly.

`start_service(SvcName, Options)` -> `ok` | `{error, Reason}`

Types:

`SvcName` = `service_name()`

`Options` = [`service_opt()`]

`Reason` = `term()`

Start a diameter service.

A service defines a locally-implemented Diameter node, specifying the capabilities to be advertised during capabilities exchange. Transports are added to a service using `add_transport/2`.

Note:

A transport can both override its service's capabilities and restrict its supported Diameter applications so "service = Diameter node as identified by Origin-Host" is not necessarily the case.

stop() -> ok | {error, Reason}

Stop the diameter application.

stop_service(SvcName) -> ok | {error, Reason}

Types:

SvcName = *service_name()*

Reason = *term()*

Stop a diameter service.

Stopping a service causes all associated transport connections to be broken. A DPR message will be sent as in the case of *remove_transport/2*.

Note:

Stopping a transport does not remove any associated transports: *remove_transport/2* must be called to remove transport configuration.

subscribe(SvcName) -> true

Types:

SvcName = *service_name()*

Subscribe to *service_event()* messages from a service.

It is not an error to subscribe to events from a service that does not yet exist. Doing so before adding transports is required to guarantee the reception of all related events.

unsubscribe(SvcName) -> true

Types:

SvcName = *service_name()*

Unsubscribe to event messages from a service.

SEE ALSO

diameter_app(3), *diameter_transport(3)*, *diameter_dict(4)*

diameterc

Command

The diameterc utility is used to compile diameter *dictionary files* into Erlang source. The resulting source implements the interface diameter requires to encode and decode the dictionary's messages and AVP's.

USAGE

diameterc [<options>] <file>

Compiles a single dictionary file. Valid options are as follows.

-o <dir>

Specifies the directory into which the generated source should be written. Defaults to the current working directory.

-i <dir>

Specifies a directory to add to the code path. Use to point at beam files compiled from inherited dictionaries, @inherits in a dictionary file creating a beam dependency, not an erl/hrl dependency.

Multiple -i options can be specified.

-E

-H

Suppresses erl and hrl generation, respectively.

--name <name>

--prefix <prefix>

Set @name and @prefix in the dictionary, respectively. Overrides any setting in the file itself.

--inherits <dict>

Append an @inherits to the dictionary before compiling. Specifying ' - ' as the dictionary has the effect of clearing any previous inherits, causing them to be ignored.

Multiple --inherits options can be specified.

EXIT STATUS

Returns 0 on success, non-zero on failure.

SEE ALSO

diameter_dict(4)

diameter_app

Erlang module

A diameter service as started by *diameter:start_service/2* configures one or more Diameter applications, each of whose configuration specifies a callback that handles messages specific to the application. The messages and AVPs of the application are defined in a dictionary file whose format is documented in *diameter_dict(4)* while the callback module is documented here. The callback module implements the Diameter application-specific functionality of a service.

A callback module must export all of the functions documented below. The functions themselves are of three distinct flavours:

- *peer_up/3* and *peer_down/3* signal the attainment or loss of connectivity with a Diameter peer.
- *pick_peer/4*, *prepare_request/3*, *prepare_retransmit/3*, *handle_answer/4* and *handle_error/4* are (or may be) called as a consequence of a call to *diameter:call/4* to send an outgoing Diameter request message.
- *handle_request/3* is called in response to an incoming Diameter request message.

Note:

The arities given for the the callback functions here assume no extra arguments. All functions will also be passed any extra arguments configured with the callback module itself when calling *diameter:start_service/2* and, for the call-specific callbacks, any extra arguments passed to *diameter:call/4*.

DATA TYPES

`capabilities() = #diameter_caps{}`

A record containing the identities of the local Diameter node and the remote Diameter peer having an established transport connection, as well as the capabilities as determined by capabilities exchange. Each field of the record is a 2-tuple consisting of values for the (local) host and (remote) peer. Optional or possibly multiple values are encoded as lists of values, mandatory values as the bare value.

`message() = record() | list()`

The representation of a Diameter message as passed to *diameter:call/4*. The record representation is as outlined in *diameter_dict(4)*: a message as defined in a dictionary file is encoded as a record with one field for each component AVP. Equivalently, a message can also be encoded as a list whose head is the atom-valued message name (the record name minus any prefix specified in the relevant dictionary file) and whose tail is a list of {FieldName, FieldValue} pairs.

A third representation allows a message to be specified as a list whose head is a `#diameter_header{}` record and whose tail is a list of `#diameter_avp{}` records. This representation is used by diameter itself when relaying requests as directed by the return value of a *handle_request/3* callback. It differs from the other two in that it bypasses the checks for messages that do not agree with their definitions in the dictionary in question (since relays agents must handle arbitrary request): messages are sent exactly as specified.

`packet() = #diameter_packet{}`

A container for incoming and outgoing Diameter messages that's passed through encode/decode and transport. Fields should not be set in return values except as documented.

`peer_ref() = term()`

A term identifying a transport connection with a Diameter peer. Should be treated opaquely.

`peer() = {peer_ref(), capabilities()}`

A tuple representing a Diameter peer connection.

`state() = term()`

The state maintained by the application callback functions *peer_up/3*, *peer_down/3* and (optionally) *pick_peer/4*. The initial state is configured in the call to *diameter:start_service/2* that configures the application on a service. Callback functions returning a state are evaluated in a common service-specific process while those not returning state are evaluated in a request-specific process.

Exports

Mod:peer_up(SvcName, Peer, State) -> NewState

Types:

```
SvcName = diameter:service_name()  
Peer = peer()  
State = NewState = state()
```

Invoked when a transport connection has been established and a successful capabilities exchange has indicated that the peer supports the Diameter application of the application on which the callback module in question has been configured.

Mod:peer_down(SvcName, Peer, State) -> NewState

Types:

```
SvcName = diameter:service_name()  
Peer = peer()  
State = NewState = state()
```

Invoked when a transport connection has been lost following a previous call to *peer_up/3*.

Mod:pick_peer(Candidates, Reserved, SvcName, State) -> {ok, Peer} | {Peer, NewState} | false

Types:

```
Candidates = [peer()]  
Peer = peer() | false  
SvcName = diameter:service_name()  
State = NewState = state()
```

Invoked as a consequence of a call to *diameter:call/4* to select a destination peer for an outgoing request, the return value indicating the selected peer.

The candidate peers list will only include those which are selected by any *filter* option specified in the call to *diameter:call/4*, and only those which have indicated support for the Diameter application in question. The order of the elements is unspecified except that any peers whose Origin-Host and Origin-Realm matches that of the outgoing request (in the sense of a *{filter, {all, [host, realm]}}* option to *diameter:call/4*) will be placed at the head of the list.

The return values *false* and *{false, State}* are equivalent when callback state is mutable, as are *{ok, Peer}* and *{Peer, State}*. Returning a peer as *false* causes *{error, no_connection}* to be returned from *diameter:call/4*. Returning a *peer()* from an initial *pick_peer/4* callback will result in a *prepare_request/3* callback followed by either *handle_answer/4* or *handle_error/4* depending on whether or not an answer message is received

from the peer. If transport with the peer is lost before this then a new *pick_peer/4* callback takes place to select an alternate peer.

Note that there is no guarantee that a *pick_peer/4* callback to select an alternate peer will be followed by any additional callbacks, only that the initial *pick_peer/4* will be, since a retransmission to an alternate peer is abandoned if an answer is received from a previously selected peer.

Note:

`{Peer, NewState}` and its equivalents can only be returned if the Diameter application in question was configured with the *diameter:application_opt()* `{call_mutates_state, true}`. Otherwise, the `State` argument is always the initial value as configured on the application, not any subsequent value returned by a *peer_up/3* or *peer_down/3* callback.

Mod:prepare_request(Packet, SvcName, Peer) -> Action

Types:

```
Packet = packet()
SvcName = diameter:service_name()
Peer = peer()
Action = {send, packet() | message()} | {discard, Reason} | discard
```

Invoked to return a request for encoding and transport. Allows the sender to access the selected peer's capabilities in order to set (for example) `Destination-Host` and/or `Destination-Realm` in the outgoing request, although the callback need not be limited to this usage. Many implementations may simply want to return `{send, Packet}`

A returned *packet()* should set the request to be encoded in its `msg` field and can set the `transport_data` field in order to pass information to the transport module. Extra arguments passed to *diameter:call/4* can be used to communicate transport data to the callback. A returned *packet()* can also set the `header` field to a `#diameter_header{}` record in order to specify values that should be preserved in the outgoing request, although this should typically not be necessary and allows the callback to set header values inappropriately. A returned `length`, `cmd_code` or `application_id` is ignored.

Returning `{discard, Reason}` causes the request to be aborted and the *diameter:call/4* for which the callback has taken place to return `{error, Reason}`. Returning `discard` is equivalent to returning `{discard, discarded}`.

Mod:prepare_retransmit(Packet, SvcName, Peer) -> Result

Types:

```
Packet = packet()
SvcName = diameter:service_name()
Peer = peer()
Result = {send, packet() | message()} | {discard, Reason} | discard
```

Invoked to return a request for encoding and retransmission. Has the same role as *prepare_request/3* in the case that a peer connection is lost and an alternate peer selected but the argument *packet()* is as returned by the initial *prepare_request/3*.

Returning `{discard, Reason}` causes the request to be aborted and a *handle_error/4* callback to take place with `Reason` as initial argument. Returning `discard` is equivalent to returning `{discard, discarded}`.

Mod:handle_answer(Packet, Request, SvcName, Peer) -> Result

Types:

```
Packet = packet()  
Request = message()  
SvcName = diameter:service_name()  
Peer = peer()  
Result = term()
```

Invoked when an answer message is received from a peer. The return value is returned from the call to *diameter:call/4* for which the callback takes place unless the detach option was specified.

The decoded answer record is in the `msg` field of the argument *packet()*, the undecoded binary in the `packet` field. Request is the outgoing request message as was returned from *prepare_request/3* or *prepare_retransmit/3* before the request was passed to the transport.

For any given call to *diameter:call/4* there is at most one call to the `handle_answer` callback of the application in question: any duplicate answer (due to retransmission or otherwise) is discarded. Similarly, only one of `handle_answer/4` or `handle_error/4` is called for any given request.

By default, an incoming answer message that cannot be successfully decoded causes the request process in question to fail, causing the relevant call to *diameter:call/4* to return `{error, failure}` (unless the detach option was specified). In particular, there is no `handle_error/4` callback in this case. Application configuration may change this behaviour as described for *diameter:start_service/2*.

Mod:handle_error(Reason, Request, SvcName, Peer) -> Result

Types:

```
Reason = timeout | failover | term()  
Request = message()  
SvcName = diameter:service_name()  
Peer = peer()  
Result = term()
```

Invoked when an error occurs before an answer message is received from a peer in response to an outgoing request. The return value is returned from the call to *diameter:call/4* for which the callback takes place (unless the detach option was specified).

Reason `timeout` indicates that an answer message has not been received within the required time. Reason `failover` indicates that the transport connection to the peer to which the request has been sent has been lost but that not alternate node was available, possibly because a *pick_peer/4* callback returned false.

Mod:handle_request(Packet, SvcName, Peer) -> Action

Types:

```
Packet = packet()  
SvcName = term()  
Peer = peer()  
Action = Reply | {relay, [Opt]} | discard | {eval, Action, PostF}  
Reply = {reply, message()} | {protocol_error, 3000..3999}  
Opt = diameter:call_opt()  
PostF = diameter:evaluable()
```

Invoked when a request message is received from a peer. The application in which the callback takes place (that is, the callback module as configured with *diameter:start_service/2*) is determined by the Application Identifier in the header of the incoming request message, the selected module being the one whose corresponding *dictionary* declares itself as defining either the application in question or the Relay application.

The argument *packet()* has the following signature.

```
#diameter_packet{header = #diameter_header{},
                  avps   = [#diameter_avp{}],
                  msg    = record() | undefined,
                  errors = [ | {, #diameter_avp{}}],
                  bin    = binary(),
                  transport_data = term() }
```

The *msg* field will be undefined only in case the request has been received in the relay application. Otherwise it contains the record representing the request as outlined in *diameter_dict(4)*.

The *errors* field specifies any Result-Code's identifying errors that were encountered in decoding the request. In this case diameter will set both Result-Code and Failed-AVP AVP's in a returned answer *message()* before sending it to the peer: the returned *message()* need only set any other required AVP's. Note that the errors detected by diameter are all of the 5xxx series (Permanent Failures). The *errors* list is empty if the request has been received in the relay application.

The *transport_data* field contains an arbitrary term passed into diameter from the transport module in question, or the atom undefined if the transport specified no data. The term is preserved in the *packet()* containing any answer message sent back to the transport process unless another value is explicitly specified.

The semantics of each of the possible return values are as follows.

```
{reply, message() }
```

Send the specified answer message to the peer.

```
{protocol_error, 3000..3999}
```

Send an answer message to the peer containing the specified protocol error. Equivalent to

```
{reply, ['answer-message' | Avps]}
```

where *Avps* sets the Origin-Host, Origin-Realm, the specified Result-Code and (if the request sent one) Session-Id AVP's.

Note that RFC 3588 mandates that only answers with a 3xxx series Result-Code (protocol errors) may set the E bit. Returning a non-3xxx value in a *protocol_error* tuple will cause the request process in question to fail.

```
{relay, Opts}
```

Relay a request to another peer in the role of a Diameter relay agent. If a routing loop is detected then the request is answered with 3005 (DIAMETER_LOOP_DETECTED). Otherwise a Route-Record AVP (containing the sending peer's Origin-Host) is added to the request and *pick_peer/4* and subsequent callbacks take place just as if *diameter:call/4* had been called explicitly. The End-to-End Identifier of the incoming request is preserved in the header of the relayed request.

The returned *Opts* should not specify *detach*. A subsequent *handle_answer/4* callback for the relayed request must return its first argument, the *#diameter_packet { }* record containing the answer message. Note that the *extra* option can be specified to supply arguments that can distinguish the relay case from others if so desired.

Any other return value (for example, from a *handle_error/4* callback) causes the request to be answered with 3002 (DIAMETER_UNABLE_TO_DELIVER).

`discard`

Discard the request.

`{eval, Action, PostF}`

Handle the request as if `Action` has been returned and then evaluate `PostF` in the request process.

Note that protocol errors detected by diameter will result in an answer message without `handle_request/3` being invoked.

diameter_dict

Name

A diameter service as configured with *diameter:start_service/2* specifies one or more supported Diameter applications. Each Diameter application specifies a dictionary module that knows how to encode and decode its messages and AVPs. The dictionary module is in turn generated from a file that defines these messages and AVPs. The format of such a file is defined in *FILE FORMAT* below. Users add support for their specific applications by creating dictionary files, compiling them to Erlang modules using *diameterc* and configuring the resulting dictionaries modules on a service.

The codec generation also results in a hrl file that defines records for the messages and grouped AVPs defined for the application, these records being what a user of the diameter application sends and receives. (Modulo other available formats as discussed in *diameter_app(3)*.) These records and the underlying Erlang data types corresponding to Diameter data formats are discussed in *MESSAGE RECORDS* and *DATA TYPES* respectively. The generated hrl also contains defines for the possible values of AVPs of type Enumerated.

The diameter application includes three dictionary modules corresponding to applications defined in section 2.4 of RFC 3588: *diameter_gen_base_rfc3588* for the Diameter Common Messages application with application identifier 0, *diameter_gen_accounting* for the Diameter Base Accounting application with application identifier 3 and *diameter_gen_relay* the Relay application with application identifier 0xFFFFFFFF. The Common Message and Relay applications are the only applications that diameter itself has any specific knowledge of. The Common Message application is used for messages that diameter itself handles: CER/CEA, DWR/DWA and DPR/DPA. The Relay application is given special treatment with regard to encode/decode since the messages and AVPs it handles are not specifically defined.

FILE FORMAT

A dictionary file consists of distinct sections. Each section starts with a tag followed by zero or more arguments and ends at the the start of the next section or end of file. Tags consist of an ampersand character followed by a keyword and are separated from their arguments by whitespace. Whitespace separates individual tokens but is otherwise insignificant.

The tags, their arguments and the contents of each corresponding section are as follows. Each section can occur multiple times unless otherwise specified. The order in which sections are specified is unimportant.

@id Number

Defines the integer Number as the Diameter Application Id of the application in question. Can occur at most once and is required if the dictionary defines @messages. The section has empty content.

The Application Id is set in the Diameter Header of outgoing messages of the application, and the value in the header of an incoming message is used to identify the relevant dictionary module.

Example:

```
@id 16777231
```

@name Mod

Defines the name of the generated dictionary module. Can occur at most once and defaults to the name of the dictionary file minus any extension if unspecified. The section has empty content.

Note that a dictionary module should have a unique name so as not collide with existing modules in the system.

Example:

```
@name etsi_e2
```

@prefix Name

Defines Name as the prefix to be added to record and constant names (followed by a '_' character) in the generated dictionary module and hrl. Can occur at most once. The section has empty content.

A prefix is optional but can be used to disambiguate between record and constant names resulting from similarly named messages and AVPs in different Diameter applications.

Example:

```
@prefix etsi_e2
```

@vendor Number Name

Defines the integer Number as the the default Vendor-Id of AVPs for which the V flag is set. Name documents the owner of the application but is otherwise unused. Can occur at most once and is required if an AVP sets the V flag and is not otherwise assigned a Vendor-Id. The section has empty content.

Example:

```
@vendor 13019 ETSI
```

@avp_vendor_id Number

Defines the integer Number as the Vendor-Id of the AVPs listed in the section content, overriding the @vendor default. The section content consists of AVP names.

Example:

```
@avp_vendor_id 2937
```

```
WWW-Auth  
Domain-Index  
Region-Set
```

@inherits Mod

Defines the name of a dictionary module containing AVP definitions that should be imported into the current dictionary. The section content consists of the names of those AVPs whose definitions should be imported from the dictionary, an empty list causing all to be imported. Any listed AVPs must not be defined in the current dictionary and it is an error to inherit the same AVP from more than one dictionary.

Note that an inherited AVP that sets the V flag takes its Vendor-Id from either @avp_vendor_id in the inheriting dictionary or @vendor in the inherited dictionary. In particular, @avp_vendor_id in the inherited dictionary is ignored. Inheriting from a dictionary that specifies the required @vendor is equivalent to using @avp_vendor_id with a copy of the dictionary's definitions but the former makes for easier reuse.

All dictionaries should typically inherit RFC3588 AVPs from diameter_gen_base_rfc3588.

Example:

```
@inherits diameter_gen_base_rfc3588
```

@avp_types

Defines the name, code, type and flags of individual AVPs. The section consists of definitions of the form

Name Code Type Flags

where Code is the integer AVP code, Type identifies an AVP Data Format as defined in *DATA TYPES* below, and Flags is a string of V, M and P characters indicating the flags to be set on an outgoing AVP or a single '-' (minus) character if none are to be set.

Example:

```
@avp_types
Location-Information 350 Grouped MV
Requested-Information 353 Enumerated V
```

Warning:

The P flag has been deprecated by the Diameter Maintenance and Extensions Working Group of the IETF and should be omitted to conform to the current draft standard.

@custom_types Mod

Specifies AVPs for which module Mod provides encode/decode functions. The section contents consists of AVP names. For each such name, `Mod:Name(encode|decode, Type, Data)` is expected to provide encode/decode for values of the AVP, where Name is the name of the AVP, Type is its type as declared in the @avp_types section of the dictionary and Data is the value to encode/decode.

Example:

```
@custom_types rfc4005_avps
Framed-IP-Address
```

@codecs Mod

Like @custom_types but requires the specified module to export `Mod:Type(encode|decode, Name, Data)` rather than `Mod:Name(encode|decode, Type, Data)`.

Example:

```
@codecs rfc4005_avps
Framed-IP-Address
```

@messages

Defines the messages of the application. The section content consists of definitions of the form specified in section 3.2 of RFC 3588, "Command Code ABNF specification".

```
@messages

RTR ::= < Diameter Header: 287, REQ, PXY >
    < Session-Id >
    { Auth-Application-Id }
    { Auth-Session-State }
    { Origin-Host }
    { Origin-Realm }
    { Destination-Host }
    { SIP-Deregistration-Reason }
    [ Destination-Realm ]
    [ User-Name ]
    * [ SIP-AOR ]
    * [ Proxy-Info ]
    * [ Route-Record ]
    * [ AVP ]

RTA ::= < Diameter Header: 287, PXY >
    < Session-Id >
    { Auth-Application-Id }
    { Result-Code }
    { Auth-Session-State }
    { Origin-Host }
    { Origin-Realm }
    [ Authorization-Lifetime ]
    [ Auth-Grace-Period ]
    [ Redirect-Host ]
    [ Redirect-Host-Usage ]
    [ Redirect-Max-Cache-Time ]
    * [ Proxy-Info ]
    * [ Route-Record ]
    * [ AVP ]
```

@grouped

Defines the contents of the AVPs of the application having type Grouped. The section content consists of definitions of the form specified in section 4.4 of RFC 3588, "Grouped AVP Values".

Example:

```
@grouped

SIP-Deregistration-Reason ::= < AVP Header: 383 >
    { SIP-Reason-Code }
    [ SIP-Reason-Info ]
    * [ AVP ]
```

Specifying a Vendor-Id in the definition of a grouped AVP is equivalent to specifying it with @avp_vendor_id.

@enum Name

Defines values of AVP Name having type Enumerated. Section content consists of names and corresponding integer values. Integer values can be prefixed with 0x to be interpreted as hexadecimal.

Note that the AVP in question can be defined in an inherited dictionary in order to introduce additional values to an enumeration otherwise defined in another dictionary.

Example:


```
@enum SIP-Reason-Code

PERMANENT_TERMINATION    0
NEW_SIP_SERVER_ASSIGNED  1
SIP_SERVER_CHANGE        2
REMOVE_SIP_SERVER        3
```

@end

Causes parsing of the dictionary to terminate: any remaining content is ignored.

Comments can be included in a dictionary file using semicolon: characters from a semicolon to end of line are ignored.

MESSAGE RECORDS

The hrl generated from a dictionary specification defines records for the messages and grouped AVPs defined in @messages and @grouped sections. For each message or grouped AVP definition, a record is defined whose name is the message or AVP name prefixed with any dictionary prefix defined with @prefix and whose fields are the names of the AVPs contained in the message or grouped AVP in the order specified in the definition in question. For example, the grouped AVP

```
SIP-Deregistration-Reason ::= < AVP Header: 383 >
                             { SIP-Reason-Code }
                             [ SIP-Reason-Info ]
                             * [ AVP ]
```

will result in the following record definition given an empty prefix.

```
-record('SIP-Deregistration-Reason' { 'SIP-Reason-Code',
                                     'SIP-Reason-Info',
                                     'AVP' } ).
```

The values encoded in the fields of generated records depends on the type and number of times the AVP can occur. In particular, an AVP which is specified as occurring exactly once is encoded as a value of the AVP's type while an AVP with any other specification is encoded as a list of values of the AVP's type. The AVP's type is as specified in the AVP definition, the RFC 3588 types being described below.

DATA TYPES

The data formats defined in sections 4.2 ("Basic AVP Data Formats") and 4.3 ("Derived AVP Data Formats") of RFC 3588 are encoded as values of the types defined here. Values are passed to *diameter:call/4* in a request record when sending a request, returned in a resulting answer record and passed to a *handle_request* callback upon reception of an incoming request.

Basic AVP Data Formats

```
OctetString() = [0..255]
Integer32()   = -2147483647..2147483647
Integer64()   = -9223372036854775807..9223372036854775807
Unsigned32()  = 0..4294967295
Unsigned64()  = 0..18446744073709551615
Float32()     = '-infinity' | float() | infinity
Float64()     = '-infinity' | float() | infinity
```

```
Grouped() = record()
```

On encode, an OctetString() can be specified as an iolist(), excessively large floats (in absolute value) are equivalent to infinity or '-infinity' and excessively large integers result in encode failure. The records for grouped AVPs are as discussed in the previous section.

Derived AVP Data Formats

```
Address() = OctetString()  
          | tuple()
```

On encode, an OctetString() IPv4 address is parsed in the usual x.x.x.x format while an IPv6 address is parsed in any of the formats specified by section 2.2 of RFC 2373, "Text Representation of Addresses". An IPv4 tuple() has length 4 and contains values of type 0..255. An IPv6 tuple() has length 8 and contains values of type 0..65535. The tuple representation is used on decode.

```
Time() = {date(), time()}  
where  
  
    date() = {Year, Month, Day}  
    time() = {Hour, Minute, Second}  
  
    Year   = integer()  
    Month  = 1..12  
    Day    = 1..31  
    Hour   = 0..23  
    Minute = 0..59  
    Second = 0..59
```

Additionally, values that can be encoded are limited by way of their encoding as four octets as required by RFC 3588 with the required extension from RFC 2030. In particular, only values between { {1968, 1, 20}, {3, 14, 8} } and { {2104, 2, 26}, {9, 42, 23} } (both inclusive) can be encoded.

```
UTF8String() = [integer()]
```

List elements are the UTF-8 encodings of the individual characters in the string. Invalid codepoints will result in encode/decode failure.

```
DiameterIdentity() = OctetString()
```

A value must have length at least 1.

```
DiameterURI() = OctetString()  
              | #diameter_URI{type = Type,  
                               fqdn = FQDN,  
                               port = Port,  
                               transport = Transport,  
                               protocol = Protocol}
```

where

```
Type = aaa | aaas
FQDN = OctetString()
Port = integer()
Transport = sctp | tcp
Protocol = diameter | radius | 'tacacs+'
```

On encode, fields port, transport and protocol default to 3868, sctp and diameter respectively. The grammar of an OctetString-valued DiameterURI() is as specified in section 4.3 of RFC 3588. The record representation is used on decode.

```
Enumerated() = Integer32()
```

On encode, values can be specified using the macros defined in a dictionary's hrl file.

```
IPFilterRule() = OctetString()
QoSFilterRule() = OctetString()
```

Values of these types are not currently parsed by diameter.

SEE ALSO

diameterc(1), *diameter(3)*, *diameter_app(3)*

diameter_transport

Erlang module

A module specified as a `transport_module` to `diameter:add_transport/2` must implement the interface documented here. The interface consists of a function with which diameter starts a transport process and a message interface with which the transport process communicates with the process that starts it (aka its parent).

Exports

```
Mod:start({Type, Ref}, Svc, Opts) -> {ok, Pid} | {ok, Pid, LAddrs} | {error, Reason}
```

Types:

```
Type = connect | accept  
Ref = diameter:transport_ref()  
Svc = #diameter_service{}  
Opts = term()  
Pid = pid()  
LAddrs = [inet:ip_address()]  
Reason = term()
```

Start a transport process. Called by diameter as a consequence of a call to `diameter:add_transport/2` in order to establish or accept a transport connection respectively. A transport process maintains a connection with a single remote peer.

The first argument indicates whether the transport process in question is being started for a connecting (`connect`) or listening (`accept`) transport. In the latter case, transport processes are started as required to accept connections from multiple peers. `Ref` is in each case the same value that was returned from the call to `diameter:add_transport/2` that has lead to starting of a transport process.

A transport process must implement the message interface documented below. It should retain the pid of its parent, monitor the parent and terminate if it dies. It should not link to the parent. It should exit if its transport connection with its peer is lost.

The capabilities in the `#diameter_service{}` record are as passed to `diameter:start_service/2` and `diameter:add_transport/2`, values passed to the latter overriding those passed to the former. The start function should use the `Host-IP-Address` list and/or `Opts` to select an appropriate list of local IP addresses, and should return this list if different from the `#diameter_service{}` addresses. The returned list is used to populate `Host-IP-Address` AVPs in outgoing capabilities exchange messages, the `#diameter_service{}` addresses being used otherwise.

MESSAGES

All messages sent over the transport interface are of the form `{diameter, term()}.`

A transport process can expect the following messages from diameter.

```
{diameter, {send, Packet}}
```

An outbound Diameter message. `Packet` can be either `binary()` (the message to be sent) or a `#diameter_packet{}` record whose `transport_data` field contains a value other than undefined and whose `bin` field contains the binary to send.

```
{diameter, {close, Pid}}
```

A request to close the transport connection. The transport process should terminate after closing the connection. `Pid` is the `pid()` of the parent process.

```
{diameter, {tls, Ref, Type, Bool}}
```

Indication of whether or not capabilities exchange has selected inband security using TLS. `Ref` is a `reference()` that must be included in the `{diameter, {tls, Ref}}` reply message to the transport's parent process (see below). `Type` is either `connect` or `accept` depending on whether the process has been started for a connecting or listening transport respectively. `Bool` is a `boolean()` indicating whether or not the transport connection should be upgraded to TLS.

If TLS is requested (`Bool=true`) then a connecting process should initiate a TLS handshake with the peer and an accepting process should prepare to accept a handshake. A successful handshake should be followed by a `{diameter, {tls, Ref}}` message to the parent process. A failed handshake should cause the process to exit.

This message is only sent to a transport process over whose `Inband-Security-Id` configuration has indicated support for TLS.

A transport process should send the following messages to its parent.

```
{diameter, {self(), connected}}
```

Inform the parent that the transport process with `Type=accept` has established a connection with the peer. Not sent if the transport process has `Type=connect`.

```
{diameter, {self(), connected, Remote}}
```

Inform the parent that the transport process with `Type=connect` has established a connection with a peer. Not sent if the transport process has `Type=accept`. `Remote` is an arbitrary term that uniquely identifies the remote endpoint to which the transport has connected.

```
{diameter, {recv, Packet}}
```

An inbound Diameter message. `Packet` can be either `binary()` (the received message) or a `#diameter_packet{}` record whose `bin` field contains the received `binary()`. Any value (other than `undefined`) set in the `transport_data` field will be passed back with a corresponding answer message in the case that the inbound message is a request unless the sender sets another value. How `transport_data` is used/interpreted is up to the transport module.

```
{diameter, {tls, Ref}}
```

Acknowledgment of a successful TLS handshake. `Ref` is the `reference()` received in the `{diameter, {tls, Ref, Type, Bool}}` message in response to which the reply is sent. A transport must exit if a handshake is not successful.

SEE ALSO

diameter_tcp(3), diameter_sctp(3)

diameter_tcp

Erlang module

This module implements diameter transport over TCP using *gen_tcp*. It can be specified as the value of a *transport_module* option to *diameter:add_transport/2* and implements the behaviour documented in *diameter_transport(3)*. TLS security is supported, both as an upgrade following capabilities exchange as specified by RFC 3588 and at connection establishment as in the current draft standard.

Note that the *ssl* application is required for TLS and must be started before configuring TLS capability on diameter transports.

Exports

start({Type, Ref}, Svc, [Opt]) -> {ok, Pid, [LAddr]} | {error, Reason}

Types:

```
Type = connect | accept
Ref = diameter:transport_ref()
Svc = #diameter_service{}
Opt = OwnOpt | SslOpt | TcpOpt
Pid = pid()
LAddr = inet:ip_address()
Reason = term()
OwnOpt = {raddr, inet:ip_address()} | {rport, integer()} | {port, integer()}
SslOpt = {ssl_options, true | list()}
TcpOpt = term()
```

The start function required by *diameter_transport(3)*.

The only diameter_tcp-specific argument is the options list. Options *raddr* and *rport* specify the remote address and port for a connecting transport and are not valid for a listening transport. Option *ssl_options* must be specified for a transport that should support TLS: a value of *true* results in a TLS handshake immediately upon connection establishment while *list()* specifies options to be passed to *ssl:connect/2* or *ssl:ssl_accept/2* after capabilities exchange if TLS is negotiated. Remaining options are any accepted by *ssl:connect/3* or *gen_tcp:connect/3* for a connecting transport, or *ssl:listen/2* or *gen_tcp:listen/2* for a listening transport, depending on whether or not *{ssl_options, true}* has been specified. Options *binary*, *packet* and *active* cannot be specified. Also, option *port* can be specified for a listening transport to specify the local listening port, the default being the standardized 3868 if unspecified. Note that the option *ip* specifies the local address.

An *ssl_options* list must be specified if and only if the transport in question has set *Inband-Security-Id* to 1 (TLS), as specified to either *start_service/2* or *add_transport/2*, so that the transport process will receive notification of whether or not to commence with a TLS handshake following capabilities exchange. Failing to specify an options list on a TLS-capable transport for which TLS is negotiated will cause TLS handshake to fail. Failing to specify TLS capability when *ssl_options* has been specified will cause the transport process to wait for a notification that will not be forthcoming, which will eventually cause the RFC 3539 watchdog to take down the connection.

If the *#diameter_service{}* record has more than one *Host-IP-Address* and option *ip* is unspecified then the first of the these addresses is used as the local address.

The returned local address list has length one.

SEE ALSO

diameter(3), diameter_transport(3), gen_tcp(3), inet(3), ssl(3)

diameter_sctp

Erlang module

This module implements diameter transport over SCTP using `gen_sctp`. It can be specified as the value of a `transport_module` option to `diameter:add_transport/2` and implements the behaviour documented in `diameter_transport(3)`.

Exports

```
start({Type, Ref}, Svc, [Opt]) -> {ok, Pid, [LAddr]} | {error, Reason}
```

Types:

```
Type = connect | accept
Ref = diameter:transport_ref()
Svc = #diameter_service{}
Opt = {raddr, inet:ip_address()} | {rport, integer()} | term()
Pid = pid()
LAddr = inet:ip_address()
Reason = term()
```

The start function required by `diameter_transport(3)`.

The only `diameter_sctp`-specific argument is the options list. Options `raddr` and `rport` specify the remote address and port for a connecting transport and not valid for a listening transport: the former is required while latter defaults to 3868 if unspecified. More than one `raddr` option can be specified, in which case the connecting transport in question attempts each in sequence until an association is established. Remaining options are any accepted by `gen_sctp:open/1`, with the exception of options `mode`, `binary`, `list`, `active` and `sctp_events`. Note that options `ip` and `port` specify the local address and port respectively.

Multiple `ip` options can be specified for a multihomed peer. If none are specified then the values of `Host-IP-Address` in the `#diameter_service{}` record are used. (In particular, one of these must be specified.) Option `port` defaults to 3868 for a listening transport and 0 for a connecting transport.

Warning:

An insufficiently large receive buffer may result in a peer having to resend incoming messages: set the `inet(3)` option `recbuf` to increase the buffer size.

An insufficiently large send buffer may result in outgoing messages being discarded: set the `inet(3)` option `sndbuf` to increase the buffer size.

`diameter_sctp` uses the `transport_data` field of the `#diameter_packet{}` record to communicate the stream on which an inbound message has been received, or on which an outbound message should be sent: the value will be of the form `{stream, Id}` on an inbound message passed to a `handle_request` or `handle_answer` callback. For an outbound message, either `undefined` (explicitly or by receiving the outbound message as a `binary()`) or a tuple should be set in the return value of `handle_request` (typically by retaining the value passed into this function) or `prepare_request`. The value `undefined` uses a "next outbound stream" id and increments this modulo the total number outbound streams. That is, successive values of `undefined` cycle through all outbound streams.

SEE ALSO

diameter_transport(3), gen_sctp(3), inet(3)