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Media Gateway Control Protocol Fax Package

Status of This Memo

This memo provides information for the Internet community. It does not specify an Internet standard of any kind. Distribution of this memo is unlimited.

Abstract

This document defines a Media Gateway Control Protocol (MGCP) package to support fax calls. The package allows for fax calls to be supported in two different ways. The first one utilizes ITU-T Recommendation T.38 for fax relay under the control of the Call Agent. The second one lets the gateway decide upon a method for fax transmission as well as handle the details of the fax call without Call Agent involvement.

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1. Introduction

This document defines a Media Gateway Control Protocol (MGCP) [RFC3435] package that enables MGCP controlled gateways to support fax calls. The package enables fax calls to be supported in two different ways. The first one utilizes ITU-T Recommendation T.38 using either UDP Transport Layer (UDPTL) or TCP (see [T38]) for fax relay under the control of the Call Agent. The second one lets the gateway decide upon a method for fax transmission as well as handle the details of the fax call without Call Agent involvement.

The fax package definition is provided in Section 2, and in Section 3 we provide three call flow examples showing how to use it. Security considerations are found in Section 4, followed by the IANA considerations and references.

1.1. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14, RFC-2119 [RFC2119].

2. Fax Package Definition

A package is defined for fax. The package defines new LocalConnectionOptions, events, and connection parameters as detailed below:

Package Name: FXR
Package Version: 0

2.1. LocalConnectionOptions

A new Fax LocalConnectionOptions (LCO) parameter is defined for fax handling. The Call Agent supplies this fax LCO to indicate the desired fax handling procedure to the Media Gateway. The fax LCO contains a list of desired fax handling procedures ordered by preference, with the most desired procedure listed first. When the parameter is explicitly included in a command, the gateway MUST be able to use at least one of the listed procedures for the command to succeed. Currently, the list can indicate one or more of the following procedures (see Sections 2.1.1 to 2.1.4 for further details on these):

- * T.38 Strict:
Use T.38 [T38] with either UDPTL or TCP for fax relay and have the Call Agent control it. Assuming the procedure can be used (see Section 2.1.1), a switch to T.38 procedures will be initiated upon fax detection, and a "t38(start)" event will be generated (see Section 2.2). This mode requires an indication of T.38 support from the remote side in order to be used, as described further in Section 2.1.1.
- * T.38 Loose:
Identical to T.38 Strict procedure, except that an indication of T.38 support from the remote side is not required for the procedure to be used.
- * Off:
Do not invoke any special procedure for fax, except for echo cancellation adjustment and possibly switching to another codec.

* Gateway:

Let the gateway control and decide how to handle fax calls without Call Agent involvement. This includes the case where the gateway does not do anything special for fax; hence, by definition this procedure can always be supported. If the gateway invokes a special procedure upon detection of fax, it will generate a "gwfax(start)" event to inform the Call Agent of this (see Section 2.2). The Call Agent SHOULD then refrain from issuing potentially conflicting commands to the gateway until the gateway ends its special fax handling procedure.

A gateway that ends up not being able to invoke any special procedure for fax will generate a "nopfax(start)" event (see Section 2.2) upon detection of fax.

The set of possible values (i.e., procedures) for the fax LCO is extensible. The prefix "x-", which indicates an optional extension, and the prefix "x+", which indicates a mandatory extension, are reserved for vendor-specific use.

In CreateConnection commands, the fax LCO value defaults to "gateway". In ModifyConnection commands, the fax LCO value defaults to its current value on the connection. Thus, if LocalConnectionOptions are omitted or if the fax LCO is not included in a ModifyConnection command, the previous fax LCO value for the connection is retained without affecting the outcome of the command; consequently, the gateway may now not apply any special procedure to fax. If the Call Agent wants to ensure that a command succeeds only when a fax procedure is applied, the command needs to include the fax LCO explicitly.

As an example of this, assume that the CreateConnection command successfully specified the use of "T.38 Strict", and a ModifyConnection command is now received without the fax LCO but with a RemoteConnectionDescriptor indicating no support for T.38. In this case, the ModifyConnection command will succeed, but T.38 procedures will no longer be invoked upon fax detection (a "nopfax" event will be generated). Had the Call Agent instead included the fax LCO set to "T.38 Strict", the command would have failed.

If multiple fax parameter values are provided, the gateway MUST choose one of the procedures specified according to the order in which they are supplied, except as follows:

1. If "gateway" would have been selected and it would have resulted in no special procedure being applied, and
2. if there are procedures other than "off" that are specified after "gateway" (e.g., "t38"),

then the gateway MUST use the most preferred of those subsequent procedures that can be supported. If none of those subsequent procedures can be supported, the gateway reverts to not invoking any special procedure for fax. Please refer to Section 2.1.4 for further details on determining which procedures can be supported.

The fax LCO parameter is encoded as the keyword "fx" (prefixed with the package name per [RFC3435]), followed by a colon and then a semicolon separated list of values, where T.38 Strict is encoded as "t38", T.38 Loose is encoded as "t38-loose", gateway is encoded as "gw", and off is encoded as "off".

The following example illustrates the use of PCMU or G.729 for audio encoding, and T.38 Strict fax relay (preferred) or gateway control for fax:

```
L: a:PCMU;G729, fxr/fx:t38;gw
```

It should be noted that MGCP allows the CreateConnection command to omit both LocalConnectionOptions and RemoteConnectionDescriptor, thereby letting the gateway decide upon the media parameters to use. When the T.38 fax package is supported, the gateway could thus choose to do either audio or T.38 fax relay in such cases. Most likely, the Call Agent requires one or the other to be used, and hence it SHOULD NOT omit both LocalConnectionOptions and RemoteConnectionDescriptor in CreateConnection commands.

When auditing capabilities, the fax LCO may be returned with a semicolon-separated list of supported fax handling parameters. The values "t38", "t38-loose", "off", and "gw" MAY be omitted from such a list as they are always implied. Gateways that implement additional parameters SHOULD return these additional parameters when capabilities are audited, as illustrated by the following example:

```
A: a:image/t38, fxr/fx:mypar, ...
```

In the following subsections, we provide additional detail on the above-defined fax procedures.

2.1.1. T.38 Procedure (Strict or Loose)

When a gateway is instructed to use one of the T.38 procedures (strict or loose), also known as Call Agent controlled T.38 mode, the "m=" line in the Session Description Protocol (SDP) returned will not indicate use of UDPTL-based or TCP-based T.38 (unless the gateway was also instructed to use "image/t38" for the media stream). Any other entity seeing this SDP will not know whether or not T.38 is supported and hence whether it is safe to attempt a switch to T.38 upon fax detection. To remedy this dilemma, capability information for T.38 (if supported) using the SDP Simple Capability Declaration extensions [RFC3407] MUST be included. Other capability information is included as well, regardless of whether the Call Agent authorized use of those in the connection handling command. A subsequent attempt to actually use these may of course not succeed, e.g., because the Call Agent LCO does not allow them to be used. The following example illustrates the RFC 3407 [RFC3407] capability descriptor--note the inclusion of both current (audio) and latent (T.38) capabilities, as specified in RFC 3407 [RFC3407]:

```
m=audio 3456 RTP/AVP 18
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 18
a=cdsc: 2 image udptl t38
```

For a list of T.38 related parameters to be included in the SDP, please refer to T.38 Annex D [T38].

Upon fax detection, a gateway that has successfully been instructed to use one of the T.38 procedures will:

1. Initiate the T.38 fax relay procedure and mute the media channel in both the send and receive direction (unless the media channel is already using T.38).
2. Generate a "t38(start)" event.
3. Await further instructions from the Call Agent in order to initiate the actual media change (unless the media channel is already using T.38).

The Call Agent instructs the gateway to perform the media change by sending it a ModifyConnection command with "image/t38" listed as the encoding method in the LocalConnectionOptions (receipt of a ModifyConnection command without LocalConnectionOptions but with a RemoteConnectionDescriptor containing an "m=" line with the MIME type "image/t38" would achieve the same). Per the normal MGCP codec negotiation procedures (see [RFC3435] Section 2.6), if a

RemoteConnectionDescriptor was included as well, it needs to include an "m=" line with "image/t38" as an acceptable media format in order for the command to succeed. The gateway may choose between the UDPTL and TCP transport protocols at its own discretion subject to the normal MGCP codec negotiation procedures (in practice, TCP-based implementations are currently rare).

If a RemoteConnectionDescriptor was not included with the ModifyConnection command sent to a gateway that initiated the T.38 procedure, it is possible (in fact likely), that the last received RemoteConnectionDescriptor did not include an "m=" line listing "image/t38" as an acceptable media format. In that case, the endpoint cannot send T.38 media to the other side. The endpoint MUST instead wait for an updated RemoteConnectionDescriptor that contains "image/t38" as an acceptable media format and a supported transport protocol (UDPTL or TCP). The T.38 fax procedure continues when an acceptable RemoteConnectionDescriptor is received. An acceptable RemoteConnectionDescriptor contains an "m=" line with the "image/t38" MIME type (using the normal SDP syntax) and a supported transport protocol (UDPTL or TCP). If the fax call fails (e.g., due to a fax timeout) while waiting for either the Call Agent to instruct the gateway to switch to "image/t38" or for an acceptable RemoteConnectionDescriptor, a "t38(stop)" or a "t38(failure)" event MUST be generated. When the T.38 procedure ends, a "t38(stop)" or "t38(failure)" event MUST be generated.

Finally, the Call Agent may need to abort a T.38 procedure that is in progress. This can for example be done when the remote side is unable to switch to T.38, and a fallback to fax passthrough using an audio codec is attempted. The Call Agent instructs the endpoint to abort an in-progress T.38 procedure by use of the "off" fax LCO as illustrated below:

```
L: fxr/fx:off
```

We now define "time t38init" as the point in time where the T.38 procedure was initiated, and "time t38abort" as the point in time where the Call Agent aborts an in-progress T.38 procedure. If the Call Agent at time t38abort instructs or enables the endpoint to revert to one or more codecs that were in use just prior to time t38init, the endpoint SHOULD use media stream parameters that mimic the most recent LocalConnectionDescriptor issued before time t38init. For example, IP-address and UDP port, payload formats used and their payload type mapping, should all be the same as before time t38init. This will enable the fallback to be as rapid as possible. A LocalConnectionDescriptor is returned as usual, i.e., only if one or

more parameters changed since the last LocalConnectionDescriptor issued (e.g., if a T.38 LCD was issued or a transport address in the audio LCD was changed).

2.1.2. Gateway Procedure

A gateway using the gateway procedure, also known as Gateway controlled mode, may initiate special fax handling upon detecting a fax call. The details of this special fax handling are outside the scope of this document. However, in order to use any special fax handling, support for it MUST be negotiated with the other side by passing and recognizing relevant parameters via the LocalConnectionDescriptor and RemoteConnectionDescriptor (this includes the use of RTP-based T.38). If the other side has not indicated support for the special fax handling desired, the gateway MUST NOT attempt to initiate it. When special fax handling is initiated, a "gwfax(start)" event MUST be generated, thereby enabling the Call Agent to differ between the Call Agent and gateway controlled mode while still being informed about the actual change to fax. When the special gateway handling of fax ends, a "gwfax(stop)" or "gwfax(failure)" event MUST be generated.

2.1.3. Off Procedure

A gateway using the "off" procedure will not invoke any special fax procedures, e.g., T.38, when detecting a fax. However, the gateway may still adjust local echo cancellation and/or switch to an alternative codec as needed. Also, a "nopfax(start)" event MUST be generated; a corresponding "stop" event, however, will not.

Generating a "stop" event would imply that the gateway had to infer when the fax call ends, which involves processing the media stream. However, when using the "off" mode, such processing is not expected to occur.

2.1.4. Mode Operation

For each of the above modes, the RemoteConnectionDescriptor provides information on what procedure(s) the other side supports. The following rules are used to determine which procedure to use:

1. Whatever the Call Agent specified in the Fax LocalConnectionOptions for the current command MUST be adhered to. If the gateway cannot satisfy any of the options, the command fails (error code 532 -- unsupported value(s) in LocalConnectionOptions is RECOMMENDED).

2. If both Fax LocalConnectionOptions and a RemoteConnectionDescriptor are provided, the procedure selected MUST be supported by both sides -- this is currently only an issue for "T.38 Strict". A procedure can be satisfied by the remote side if:

- * the relevant MIME media type, e.g., "image/t38", is included in the "m=" line in the RemoteConnectionDescriptor, or

- * the relevant MIME media type is included as a capability (see [RFC3407]) in the RemoteConnectionDescriptor.

If the gateway cannot select any of the procedures in the Fax LocalConnectionOptions, the command fails (error code 532 is RECOMMENDED). Note that "T.38 Loose", "gateway", and "off" -- by definition -- can always be supported by an implementation that supports this package, irrespective of what the RemoteConnectionDescriptor indicates.

3. If the Call Agent did not include any Fax LocalConnectionOptions or a RemoteConnectionDescriptor with the command, the gateway MUST continue using whichever procedure it is currently using.
4. If the Call Agent did not include any Fax LocalConnectionOptions, but a RemoteConnectionDescriptor was included, the gateway MUST follow rule 2 in selecting a procedure. In so doing, the default Fax LocalConnectionOptions, i.e., "gateway" in CreateConnection, or the current value in ModifyConnection, MUST be used. In the case of ModifyConnection, the outcome of the command does not depend on the gateway being able to select one of these "default" procedures (as described in Section 2.1). Note that this is not an issue for the CreateConnection command, since the default value can always be supported by definition.
5. A previously received RemoteConnectionDescriptor does not affect what procedure can be selected. Only a RemoteConnectionDescriptor supplied with the current command affects the procedure selection. However, in order to send media of a given type (e.g., "image/t38"), the most recently received RemoteConnectionDescriptor MUST include a corresponding media line.

The following examples illustrate the use of the above rules:

Per rule 1, a gateway that only supports standard T.38 fax relay will fail a command that only contains the fax option "mypar", whereas it will succeed a command that contains "t38-loose", "gw", "off", or no fax LCO. A command that only contained "t38", i.e., use of T.38 in "strict" mode, may or may not succeed (depending on the RemoteConnectionDescriptor).

A gateway supporting T.38 that receives a CreateConnection command with the fax handling LCO set to "t38" and a RemoteConnectionDescriptor with neither a T.38 capability nor a T.38 media stream will fail per rule 2. Had the fax handling LCO included either "t38-loose", "gw" or "off", the command would have succeeded, and any of the procedures included could have been selected.

Assume a gateway supporting T.38 has successfully executed a CreateConnection command with fax handling set to "t38" (i.e., strict). If the gateway now receives a ModifyConnection command without a fax handling LCO but with a RemoteConnectionDescriptor that has neither a T.38 capability nor a media stream with "image/t38", the command will succeed (since rule 1 has no effect in that case). However, per rule 2 and 4, there will not be any T.38 procedure in place. Had the Call Agent instead included a fax handling LCO set to "t38" again, the command would have failed per rule 2.

Finally, it should be noted that a switch to T.38 can be initiated by either one or both of the originating and terminating gateways and hence implementations MUST be prepared to handle this. This includes the case where both sides initiate the switch, which for example can occur when the originating fax generates Calling Tone (CNG) and the terminating fax detects V.21 fax preamble (see [T30]) before the switch to T.38 has been performed on the terminating side.

2.1.5. Detecting a Fax Call

A fax call can be detected by several different means (e.g., V.21 fax preamble, T.30 CNG tone, or V.8 signals) depending on the fax transmission method being used. Implementations of this package MUST at a minimum detect a fax call based on V.21 fax preamble.

Triggering based on T.30 CNG tone MAY be done; this is generally considered acceptable for G3 and lower fax speeds. However, when used with T.38 version 2 or earlier, it will impact V.34 high-speed fax. The reason is that T.38 version 2 (and earlier) does not support the V.8 ANSam and CM signals used with V.34 fax, and hence the V.34 faxes will downspeed to G3 (14.400 bps) or lower when using T.38 version 2 (or earlier). Also, a few rare cases of modems

generating T.30 CNG tones for non-fax calls have been reported; such modems would generate a false trigger for fax. As a consequence of the above, it is RECOMMENDED that implementations of this package that support T.30 CNG-based fax detection provide a configuration option to disable it for T.38 version 2 (or earlier).

2.1.6. Considerations for Determining Which Procedures to Request

It is important to understand the implications of using any one of the above defined procedures. Furthermore, multiple alternative procedures can be requested, however not all combinations make sense. In this section, we elaborate on both of these issues.

Use of the T.38 Strict mode is ideal in an environment where it is known that other endpoints generate RFC 3407 [RFC3407] capability descriptions with T.38 fax relay information. If a RemoteConnectionDescriptor without T.38 fax relay capabilities is received in such an environment, it is known that the other side does not support T.38, and hence an unsuccessful attempt to switch to T.38 (which in turn may lead to a failed fax call) can be avoided. If it is not known whether other endpoints support the RFC 3407 [RFC3407] capability descriptors, the trade-off is less clear. The advantage is that a switch to T.38 will only be attempted if it is known that the other side supports it, but endpoints that do not indicate support for T.38 may still support it; however, T.38 will not be used with these, which in turn may lead to unnecessary fax failures with low-bandwidth codecs or lossy networks.

Use of the T.38 loose mode involves the same considerations as for T.38 Strict, however the pros and cons are reversed. If a peer endpoint does not support T.38, the T.38 loose mode will still attempt to switch to T.38 (and fail), which in turn may lead to a failed fax call. On the other hand, if the peer endpoint does not support the RFC 3407 [RFC3407] capability descriptors, but the peer endpoint does in fact support T.38, T.38 would still be used with this mode.

In summary, there is no single good answer to the use of either T.38 Strict or T.38 loose mode; it depends on the capabilities of the endpoints involved as well as the trade-off between potentially letting fax calls fail due to lack of capability indications (where T.38 is otherwise supported) versus potentially letting fax calls fail due to an unsuccessful switch to T.38 (because T.38 in fact was not supported). It should be noted that Call Agents may have means beyond RFC 3407 [RFC3407] capability descriptors to determine if a peer endpoint supports T.38 or not. For example, when SIP is used as the signaling protocol with other peers (e.g., Call Agents or other SIP devices), the SIP OPTIONS method can be used to learn whether

T.38 is supported. Also, if the Call Agent allows use of high-bandwidth codecs with redundancy when support for T.38 is not indicated, fax calls may still succeed without the use of T.38, even in networks with non-negligible packet loss.

When the gateway controlled mode is selected, there will only be special fax handling if the two peer endpoints support the same fax handling method; note that the details of the actual method is entirely up to the vendor. Also note that if the two peer endpoints do not support the same method for fax handling or if the method is not indicated in the SDP exchanged, there will be no special fax handling in place. Furthermore, the Call Agent will not be aware that this is the case until the fax transmission starts and a "nopfax(start)" event is generated.

The off mode is straightforward; there will be no special procedure in place for fax handling, except for the usual handling of echo cancellation and possibly a change to a higher bandwidth codec.

Having looked at the individual procedures in more detail, we now elaborate on some of the combinations of procedures that may be requested:

* T.38 strict:

If the T.38 strict procedure is placed after the T.38 loose or the off procedure (both of which can always be supported), it will not be selected. Apart from this, it makes little sense to request both T.38 strict and T.38 loose.

* T.38 loose:

The T.38 loose procedure can always be supported, so any procedure specified after T.38 loose will not be selected.

* Gateway:

The gateway controlled procedure can always be supported. If the gateway controlled procedure would have resulted in no special fax procedure and further options (except off) are provided, those procedures will be attempted. If neither of those procedures can be supported, there will be no special fax procedure in place.

* Off:

The off procedure can always be supported. Any procedure specified after this one will not be selected.

2.2. Events and Signals

The following events are defined in support of the above:

Symbol	Definition	R	S	Duration
gwfax	Gateway controlled fax	x		
nopfax	No special fax handling	x		
t38	T.38 fax relay	x		

The definitions of the individual events are provided in the following subsections.

2.2.1. Gateway Controlled Fax (gwfax)

The "gateway controlled fax" event occurs when the gateway handled fax procedure either starts, stops, or fails. The event is encoded as "gwfax", and the following event parameters, which apply to ObservedEvents only, are defined:

* start:

Gateway controlled fax procedure was initiated. The Call Agent SHOULD refrain from issuing media handling instructions to the gateway until either a "gwfax(stop)" or "gwfax(failure)" event is generated.

* stop:

Gateway controlled fax procedure ended and the gateway did not detect any errors. Note that this does not necessarily imply a successfully transmitted fax. It merely indicates that the gateway controlled fax procedure has ended and the procedure itself did not encounter any errors. Media parameters for the connection are as before the gateway handled fax procedure started.

* failure:

The gateway controlled fax procedure ended abnormally. Some kind of problem was encountered in the gateway controlled fax procedure, and the procedure ended. Media parameters are as before the gateway handled fax procedure started.

One of the above parameters will be present when the event is reported. The "gwfax" event MAY be parameterized with additional parameters in ObservedEvents, however it is RECOMMENDED that one of the above parameters is the first parameter supplied. Unknown parameters MUST be ignored.

The following example illustrates the encoding of the "gwfax" event:

```
O: fxr/gwfax(start)
O: fxr/gwfax(stop, foobar)
```

2.2.2. No Special Fax Handling (nopfax)

The "no special fax handling" event occurs when there is no special fax handling procedure in place and a fax call is detected. This can happen either because no special fax handling procedure was requested (including "off") or negotiation resulted in no special fax handling procedure being supported. The event is encoded as "nopfax", and the following event parameter, which applies to ObservedEvents only, is defined:

*** start:**

No special fax handling procedure is in place, however a fax call is now detected. The Call Agent may have to issue further commands in order to ensure a successful fax call (e.g., switch to another codec).

The above parameter will be present when the event is reported. The "nopfax" event MAY be parameterized with additional parameters on ObservedEvents, however it is RECOMMENDED that the above parameter is the first parameter supplied. Unknown parameters MUST be ignored. Note that this event currently cannot be parameterized with "stop" or "failure" as it only detects the beginning of a fax call.

The following example illustrates the encoding of the "nopfax" event:

```
O: fxr/nopfax(start)
```

2.2.3. T.38 Fax Relay (t38)

The "T.38 fax relay" event occurs when one of the T.38 fax relay procedures (strict or loose) either starts, stops, or fails. The event is encoded as "t38", and the following event parameters, which apply to ObservedEvents only, are defined:

*** start:**

A fax call was detected on the endpoint and the Call Agent controlled T.38 fax relay procedure was initiated. The Call Agent SHOULD modify each side of the connection to start using the "image/t38" media format, unless they already do. Note that, as long as use of the Call Agent controlled T.38 relay procedure is in effect, the event will be generated upon fax call detection, irrespective of the current encoding method on any connections on the endpoint (incl. "image/t38"). The "t38(start)" event MUST be

generated at most once by the endpoint per fax call, regardless of whether or not it is requested again in a subsequent requested events list.

* stop:

Call Agent controlled T.38 fax relay procedure ended and the gateway did not detect any errors. Note that this does not necessarily imply a successfully transmitted fax. It merely indicates that the Call Agent controlled T.38 fax relay procedure has ended and the procedure itself did not encounter any errors. The Call Agent may want to modify the media parameters for each side of the connection. Note that, in contrast to the gateway controlled fax procedure case, media parameters such as codecs do not automatically revert to their values before the start of the fax call; however, echo cancellation and silence suppression do per the procedures in [RFC3435] Section 2.3.5. The "t38(stop)" event MUST NOT be generated unless a corresponding "t38(start)" event for the fax call in question was generated earlier.

* failure:

Call Agent controlled T.38 fax relay procedure ended abnormally. Some kind of problem in the Call Agent controlled T.38 fax relay procedure was encountered, and the procedure ended. The Call Agent may want to modify the media parameters for each side of the connection. Note that, in contrast to the gateway controlled fax procedure case, media parameters such as codecs do not automatically revert to their state before the start of the fax call; however, echo cancellation and silence suppression do per the procedures in [RFC3435] Section 2.3.5. The "t38(failure)" event MUST NOT be generated unless a corresponding "t38(start)" event for the fax call in question was generated earlier.

One of the above parameters will be present when the event is reported. The "t38" event MAY be parameterized with additional parameters, however it is RECOMMENDED that one of the above parameters is the first parameter supplied. Unknown parameters MUST be ignored.

The following example illustrates the encoding of the "t38" event:

```
O: fxr/t38(start)
O: fxr/t38(stop, foobar)
```

2.3. Connection Parameters

The connection parameters for the connection, that measures packets and octets sent and received, MUST include packets and octets for fax handling as well. Interarrival jitter and average transmission delay

calculation however MAY NOT be performed while fax is in progress, e.g., if T.38 is used. In such cases, the interarrival jitter and average transmission delay calculations are simply suspended until calculations can resume, e.g., by changing back to an RTP-based media stream.

In addition to these connection parameters, the fax package defines the following connection parameters, which gateways MAY support:

Number of fax pages sent (PGS):

The cumulative number of fax pages sent by the endpoint for the life of the connection. The parameter is encoded as "PGS", and the value supplied is a string of up to nine decimal digits.

Number of fax pages received (PGR):

The cumulative number of fax pages received by the endpoint for the life of the connection. The parameter is encoded as "PGR", and the value supplied is a string of up to nine decimal digits.

The following example illustrates the use of these parameters:

P: FXR/PGS=3, FXR/PGR=0, PS=1245, OS=62345, ...

2.4. Negotiation of T.38 Parameters

T.38 Annex D [T38] defines a number of T.38 parameters that can be negotiated in the SDP. Currently, T.38 does not specify procedures for how each of these parameters is negotiated or in particular whether each side has to use the same value. Therefore, we considered adding such definitions and procedures here. However, it is expected that T.38 will rectify the above, which could lead to conflicting definitions and procedures. To avoid that, we instead assume the existence of an offer/answer [RFC3264] section for T.38, where T.38 Annex D parameters are classified as either declarative or negotiated, and we then provide guidelines for how to map such definitions and procedures to the MGCP fax package defined here.

MGCP does not specify use of the offer/answer model but instead operates with the concept of connection handling commands (e.g., CreateConnection and ModifyConnection) that may include a RemoteConnectionDescriptor (SDP) and in turn may generate a LocalConnectionDescriptor (SDP) in their response.

When an MGCP endpoint receives a CreateConnection command without a RemoteConnectionDescriptor, it should follow the corresponding T.38 procedures for generating an initial offer and return the resulting SDP in its LocalConnectionDescriptor.

When an MGCP endpoint receives a CreateConnection command with a RemoteConnectionDescriptor, it should follow the corresponding T.38 procedures for receiving an initial offer and generating an answer to it. The resulting SDP is returned in the LocalConnectionDescriptor.

When an MGCP endpoint receives a ModifyConnection command with a RemoteConnectionDescriptor, it cannot determine whether this corresponds to an answer to an initial offer or to a new offer. This is not an issue for declarative parameters since they can be specified independently in either direction. Negotiated parameters, however, require some consideration:

When an offerer receives an answer to a previous offer, the negotiation has completed and the parameters negotiated can no longer be changed with this offer/answer exchange. The negotiated parameters may be subject to certain validation checks. Conversely, when an answerer receives an offer, the negotiation is open and the answerer may change some of the offered negotiated parameters. Since the MGCP endpoint does not know which situation it is in, it cannot perform the "offerer" validation checks. Likewise, in order to ensure that any required negotiation actually takes place, it needs to process an incoming SDP as an offer. If the SDP in fact does correspond to an offer, then this is obviously correct behavior. However, if the SDP corresponds to an answer, and one or more negotiated parameters did change, then this will result in a new SDP. The Call Agent may or may not contain sufficient intelligence to determine whether or not this new SDP needs to result in another offer/answer exchange.

For example, if the initial offer (in response to a CreateConnection without SDP) contained fax version 2, and the answer (in response to a CreateConnection with SDP) contained fax version 0, then the corresponding ModifyConnection command (with SDP) will result in an updated SDP with fax version also set to zero. If this was the only change in the updated SDP, a new offer/answer exchange would not be needed. Note that this example does not imply that it is generally considered a good idea for Call Agents to parse SDP in order to determine whether or not new offer/answer exchanges are needed.

Finally, a ModifyConnection without SDP that generates an SDP needs to be considered. The SDP generated may either correspond to an initial offer/answer exchange or a subsequent offer/answer exchange.

The endpoint should generate SDP as if it was part of a subsequent offer/answer exchange. If the Call Agent does not desire such semantics, it can simply create a new connection instead.

2.5. Implementation Considerations

2.5.1. Media IP Address and Port for T.38

When an endpoint is instructed to change to or from T.38 for a media stream, it SHOULD continue using the same IP address and port the media stream is currently using, since this will minimize any Quality of Service, Network Address Translator (NAT), and Firewall interactions from the change. However, if an endpoint has a good reason, it MAY choose not to follow this recommendation.

When an endpoint uses the same port for RTP audio and T.38 with either UDPTL or TCP, packets of one type (e.g., T.38) may be received while expecting packets of another type (RTP audio). Since there is explicit signaling to indicate which type is expected at any given point in time, this does not introduce any new problems. In other words, the receiver does not operate as a demultiplexer with a need to determine if a given packet received is an RTP audio packet or a T.38 UDPTL/TCP packet. The receiver simply processes incoming packets as usual. If T.38 packets are expected, then incoming packets are validated against T.38, and if RTP audio packets are expected, then incoming packets are validated against RTP.

2.5.2. Case Sensitivity

IANA has registered the uppercase string "UDPTL" as the transport protocol identifier to be used for UDP-based T.38. However, the examples provided in Recommendation T.38, as well as most (if not all) current implementations, use the lowercase string "udptl" instead. Implementations conforming to this package SHOULD generate the lowercase string "udptl" and accept the lowercase, uppercase, and mixed upper/lowercase strings as being equivalent.

The attribute "T38MaxBitRate" was once incorrectly registered with IANA as "T38maxBitRate" (lower-case "m"). In accordance with T.38 examples and common implementation practice, the form "T38MaxBitRate" SHOULD be generated by implementations conforming to this package.

In general, it is RECOMMENDED that implementations of this package accept lowercase, uppercase, and mixed upper/lowercase encodings of all the T.38 attributes.

2.5.3. Boolean Indicator After T.38 Parameters

Some implementations incorrectly use a colon (':') followed by a number (zero or one) after the attributes T38FaxFillBitRemoval, T38FaxTranscodingMMR, and T38FaxTranscodingJBIG. Implementations that receive such erroneous encodings MAY interpret the value ":0" as lack of support for the option and all other values as support for the option.

3. Call Flow Examples

In this section, we provide three example call flows. The first one illustrates a T.38 fax call under Call Agent control on both the originating and terminating side. The second one illustrates the use of multiple and different options on the two sides. The third one illustrates the interaction with a SIP endpoint.

3.1. Call Agent Controlled T.38 Strict

In this example, both sides are under strict T.38 Call Agent control. We assume the originating and terminating Call Agents communicate via the Session Initiation Protocol (SIP) [RFC3261]. Furthermore, the originating fax machine does not generate CNG tone, which is typical of early (i.e., pre-1993) fax machines.

#	GW-o	CA-o	CA-t	GW-t
1		<- CRCX		
2	200 (sdp-o)	->		
3		INVITE (sdp-o)	->	
4			CRCX (sdp-o)	->
5				<- 200 (sdp-t)
6			<- 200 (sdp-t)	
7	<- MDCX (sdp-t)			
8	200	->		
9				<- ANS/ T.30 CED
10				<- V.21 fax preamble
11				<- NTFY (t38 start)
12			200	->
13			MDCX (t38)	->
14				<- 200 (sdp-t2)
15			<- INVITE (sdp-t2)	
16	<- MDCX (sdp-t2)			
17	200 (sdp-o2)	->		
18		200 (sdp-o2)	->	
19			MDCX (sdp-o2)	->
20				<- 200
21	V.21 fax -> preamble			
22	NTFY (t38 start)	->		
23		<- 200		
24		<- RQNT (T38 event)		
25	200	->		
26				(fax ends)
27				<- NTFY (t38 stop)
28			200	->
29	NTFY (t38 stop)	->		
30		<- 200		

Step 1:

The Call Agent issues a CreateConnection command to the gateway, instructing it to use PCMU media encoding and to use the strict Call Agent controlled T.38 procedure. Consequently, the Call Agent asks the gateway to notify it of the "t38" event:

```
CRCX 1000 ds/ds1-1/1@gw-o.example.net MGCP 1.0
C: 1
L: a:PCMU, fxr/fx:t38
M: recvonly
R: fxr/t38
X: 1
```

Step 2:

The gateway acknowledges the command and includes SDP with codec information and RFC 3407 [RFC3407] capability information:

```
200 1000 OK
I:1

v=0
o=- 25678 753849 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=audio 3456 RTP/AVP 0
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38
```

Step 3:

The originating Call Agent sends a SIP INVITE message with the SDP to the terminating Call Agent.

Step 4:

The terminating Call Agent issues a CreateConnection command to the terminating gateway, instructing it to use PCMU media encoding and to use the strict Call Agent controlled T.38 procedure. Consequently, the Call Agent asks the gateway to notify it of the "t38" event:

```
CRCX 2000 ds/ds1-1/2@gw-t.example.net MGCP 1.0
C: 2
L: a:PCMU, fxr/fx:t38
M: sendrecv
R: fxr/t38
X: 20

v=0
o=- 25678 753849 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=audio 3456 RTP/AVP 0
a=sn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38
```

Step 5:

The terminating gateway supports T.38, and the RemoteConnectionDescriptor included indicates that the other side supports T.38 as well, so the strict T.38 Call Agent controlled procedure requested can be used. The terminating gateway sends back a success response with its SDP, which also includes capability information:

```
200 2000 OK
I:2

v=0
o=- 25678 753849 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=audio 1296 RTP/AVP 0
a=sn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38
```

Step 6:

The terminating Call Agent sends back a SIP 200 OK response to the originating Call Agent, which in turn sends a SIP ACK (not shown).

Step 7:

The originating Call Agent in turn sends a ModifyConnection command to the originating gateway:

```
MDCX 1001 ds/ds1-1/1@gw-o.example.net MGCP 1.0
C: 1
I: 1
M: sendrecv

v=0
o=- 25678 753849 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=audio 1296 RTP/AVP 0
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38
```

The ModifyConnection command does not repeat the LocalConnectionOptions sent previously. As far as fax handling is concerned, the gateway therefore attempts to continue using the current fax handling procedure, i.e., strict Call Agent controlled T.38. Since the capability information indicates the other side supports T.38, the gateway will in fact be able to use the strict Call Agent controlled T.38 procedure. Had there not been any support for T.38 in the RemoteConnectionDescriptor, then this command would still have succeeded, however there would be no special fax handling procedure (since strict mode could not be supported).

Step 8:

The gateway acknowledges the command. At this point, a call is established using PCMU encoding, and if a fax call is detected, the Call Agent controlled T.38 procedure will be initiated.

Steps 9-11:

A fax call now occurs. The T.30 CED tone (a.k.a. V.25 ANS) is sent -- in this case, it is simply passed through the current PCMU encoding. Since both fax and modem calls can start with this sequence, it is not possible to determine that this is a fax call until step 10, where the V.21 fax preamble is detected.

The gateway was instructed to apply the Call Agent controlled T.38 procedure for fax calls, so it begins to mute audio, generates the "t38(start)" event, and notifies the Call Agent:

```
NTFY 2500 ds/ds1-1/2@gw-t.example.net MGCP 1.0
O: fxr/t38(start)
X: 20
```

Step 12:

The Call Agent acknowledges the Notify command:

```
200 2500 OK
```

Step 13:

The Call Agent then instructs the terminating gateway to use the "image/t38" MIME type instead:

```
MDCX 2002 ds/ds1-1/2@gw-t.example.net MGCP 1.0
C: 2
I: 2
L: a:image/t38
R: fxr/t38
X: 21
```


Step 14:

The gateway changes to T.38 and sends back a success response with updated SDP:

```
200 2002 OK

v=0
o=- 25678 753850 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=image 1296 udpt1 t38
a=sgn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udpt1 t38
```

Note that since the gateway's current RemoteConnectionDescriptor (as opposed to the LocalConnectionDescriptor returned here) does not list "image/t38" as a valid encoding method, the terminating gateway is still muting the media and is now waiting for an updated RemoteConnectionDescriptor with "image/t38".

Step 15:

The terminating Call Agent sends a re-INVITE to the originating Call Agent with the updated SDP.

Step 16:

The originating Call Agent then sends a ModifyConnection command to the originating gateway:

```
MDCX 1003 ds/ds1-1/1@gw-o.example.net MGCP 1.0
C: 1
I: 1

v=0
o=- 25678 753850 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=image 1296 udpt1 t38
a=sgn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udpt1 t38
```

Step 17:

The originating gateway changes to T.38 and sends back a success response with updated SDP:

```
200 1003 OK

v=0
o=- 25678 753850 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=image 3456 udpt1 t38
a=sgn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udpt1 t38
```

Step 18:

The originating Call Agent sends a SIP 200 OK response with the updated SDP to the terminating Call Agent, which in turn sends a SIP ACK (not shown).

Step 19:

The terminating Call Agent sends a ModifyConnection with the updated SDP to the terminating gateway:

```
MDCX 2003 ds/ds1-1/2@gw-t.example.net MGCP 1.0
C: 2
I: 2

v=0
o=- 25678 753850 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=image 3456 udpt1 t38
a=sgn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udpt1 t38
```

Step 20:

The terminating gateway sends back a success response:

```
200 2003 OK
```

Since the terminating gateway now has a RemoteConnectionDescriptor with "image/t38" as valid media, it can start exchanging T.38 with the originating gateway.

Steps 21, 22:

The originating endpoint detects V.21 fax preamble. Even though the endpoint is already using "image/t38" for media, it generates a "t38(start)" event and notifies the Call Agent.

```
NTFY 3500 ds/ds1-1/1@gw-o.example.net MGCP 1.0
O: fxr/t38(start)
X: 1
```

Steps 23, 24:

The Call Agent acknowledges the Notify command, then issues a new request for notification of the "t38" event.

```
200 3500 OK
.
RQNT 1004 ds/ds1-1/1@gw-o.example.net MGCP 1.0
R: fxr/t38
X: 2
```

Step 25:

The gateway acknowledges the command.

```
200 1004 OK
```

Steps 26, 27:

When the fax ends, a "t38(stop)" event is generated by the terminating endpoint, which is notified to the Call Agent:

```
NTFY 2501 ds/ds1-1/2@gw-t.example.net MGCP 1.0
O: t38(stop)
X: 21
```

Step 28:

The Call Agent acknowledges the Notify command:

```
200 2501 OK
```

Step 29:

The originating endpoint also generates a "t38(stop)" event, which is notified to the Call Agent:

```
NTFY 3502 ds/ds1-1/1@gw-o.example.net MGCP 1.0
O: t38(stop)
X: 2
```

Step 30:

The Call Agent acknowledges the Notify command:

```
200 3502 OK
```

The fax call is now over. The Call Agent may now decide to change back to a voice codec, delete the connection, or do something different.

3.2. Multiple and Different Options

In this example, the originating gateway is instructed to use the gateway procedure, whereas the terminating gateway is given a choice between the gateway procedure and the strict t38 procedure. Furthermore, the originating fax machine is generating CNG tone.

#	GW-o	CA-o	CA-t	GW-t
1		<- CRCX		
2	200 (sdp-o)	->		
3		INVITE (sdp-o)	->	
4			CRCX (sdp-o)	->
5				<- 200 (sdp-t)
6			<- 200 (sdp-t)	
7	<- MDCX (sdp-t)			
8	200	->		
9	CNG	->		
10				<- ANS/T.30 CED
11				<- V.21 fax preamble
12				<- NTFY (t38 start)
13			200	->
14			MDCX (t38)	->
15				<- 200 (sdp-t2)
16			<- INVITE (sdp-t2)	
17	<- MDCX (sdp-t2)			
18	200 (sdp-o2)	->		
19		200 (sdp-o2)	->	
20			MDCX (sdp-o2)	->
21				<- 200
22				(fax ends)
23				<- NTFY (t38 stop)
24			200	->

Step 1:

The Call Agent issues a CreateConnection command to the gateway, instructing it to use PCMU media encoding and to use the gateway procedure. Consequently, the Call Agent asks the gateway to notify it of the "gwfax" event:

```
CRCX 1000 ds/ds1-1/1@gw-o.example.net MGCP 1.0
C: 1
L: a:PCMU, fxr/fx:gw
M: recvonly
R: fxr/gwfax
X: 1
```

Step 2:

The gateway acknowledges the command and includes SDP with codec information and capability information:

```
200 1000 OK
I:1

v=0
o=- 25678 753849 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=audio 3456 RTP/AVP 0
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38
a=X-FaxScheme: 123
```

We assume the gateway supports some other fax scheme, and it indicates this by including an attribute "X-FaxScheme: 123".

Step 3:

The originating Call Agent sends a SIP INVITE message with the SDP to the terminating Call Agent.

Step 4:

The terminating Call Agent issues a CreateConnection command to the terminating gateway, instructing it to use PCMU media encoding and to use either the gateway procedure or the strict Call Agent controlled T.38 procedure. Consequently, the Call Agent asks the gateway to notify it of both the "gwfax" and "t38" events:

```

CRCX 2000 ds/ds1-1/2@gw-t.example.net MGCP 1.0
C: 2
L: a:PCMU, fxr/fx:gw;t38
M: sendrecv
R: fxr/t38, fxr/gwfax
X: 20

v=0
o=- 25678 753849 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=audio 3456 RTP/AVP 0
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38
a=X-FaxScheme: 123

```

Step 5:

The terminating gateway does not support any special gateway fax handling; however, it does support T.38, and the RemoteConnectionDescriptor included indicates that the other side supports T.38 as well, so the strict T.38 Call Agent controlled procedure requested can be honored. The terminating gateway sends back a success response with its SDP, which also includes capability information:

```

200 2000 OK
I:2

v=0
o=- 25678 753849 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=audio 1296 RTP/AVP 0
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38

```

Step 6:

The terminating Call Agent sends back a SIP 200 OK response to the originating Call Agent, which in turn sends a SIP ACK (not shown).

Step 7:

The originating Call Agent in turns sends a ModifyConnection command to the originating gateway:

```
MDCX 1001 ds/ds1-1/1@gw-o.example.net MGCP 1.0
C: 1
I: 1
M: sendrecv

v=0
o=- 25678 753849 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=audio 1296 RTP/AVP 0
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38
```

The ModifyConnection command does not repeat the LocalConnectionOptions sent previously. As far as fax handling is concerned, the gateway therefore attempts to continue using the current fax handling, i.e., the gateway procedure. The SDP information returned however does not indicate support for the "X-FaxScheme: 123", and hence the originating gateway will not invoke any special fax handling procedure for this call.

Step 8:

The gateway acknowledges the command. At this point, a call is established using PCMU encoding, and if a fax call is detected, no special fax handling procedure will occur.

Steps 9-12:

A CNG tone is generated by the originating fax, thereby indicating a fax call. If the gateway was using either of the T.38 modes, or if it had negotiated support for a special gateway handling procedure with the other side, a "t38(start)" or "gwfax(start)" event would now have been generated and the switch to T.38 (or special gateway handling) could start. However, since the negotiation with the terminating gateway resulted in the originating gateway not doing anything special for fax, no such event is generated. Instead, the "nopfax(start)" event is now generated, but since the Call Agent has not requested this event, it is not detected and hence not reported to the Call Agent. Consequently, the CNG tone is simply passed through the current PCMU encoding without the (originating) Call Agent being aware of the fax call.

Subsequently, the T.30 CED tone (a.k.a. V.25 ANS) occurs -- in this case, it is also simply passed through the current PCMU encoding. Since both fax and modem calls can start with this sequence, it is not possible to determine that this is a fax call until step 11, where the V.21 fax preamble is detected.

The terminating gateway is using the Call Agent controlled T.38 procedure for fax calls, so it begins to mute audio, generates the "t38(start)" event, and notifies the Call Agent:

```
NTFY 2500 ds/ds1-1/2@gw-t.example.net MGCP 1.0
O: fxr/t38(start)
X: 20
```

Step 13:

The Call Agent acknowledges the Notify command:

```
200 2500 OK
```

Step 14:

The Call Agent then instructs the terminating gateway to use the "image/t38" MIME type instead:

```
MDCX 2002 ds/ds1-1/2@gw-t.example.net MGCP 1.0
C: 2
I: 2
L: a:image/t38
R: fxr/t38
X: 21
```

Step 15:

The gateway changes to T.38 and sends back a success response with updated SDP:

```
200 2002 OK

v=0
o=- 25678 753850 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=image 1296 udptl t38
a=sgn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38
```

Note that since the terminating gateway's last received RemoteConnectionDescriptor (as opposed to the LocalConnectionDescriptor returned here) did not list "image/t38" as a valid encoding method, the terminating gateway is still muting the media and is now waiting for an updated RemoteConnectionDescriptor with "image/t38".

Step 16:

The terminating Call Agent sends a re-INVITE to the originating Call Agent with the updated SDP.

Step 17:

The originating Call Agent then sends a ModifyConnection command to the originating gateway:

```
MDCX 1003 ds/ds1-1/1@gw-o.example.net MGCP 1.0
C: 1
I: 1

v=0
o=- 25678 753850 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=image 1296 udptl t38
a=sgn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38
```

Step 18:

The originating gateway changes to T.38 and sends back a success response with updated SDP:

```
200 1003 OK

v=0
o=- 25678 753850 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=image 3456 udpt1 t38
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udpt1 t38
```

Step 19:

The originating Call Agent sends a SIP 200 OK response with the updated SDP to the terminating Call Agent, which in turn sends a SIP ACK (not shown).

Step 20:

The terminating Call Agent sends a ModifyConnection with the updated SDP to the terminating gateway:

```
MDCX 2003 ds/ds1-1/2@gw-t.example.net MGCP 1.0
C: 2
I: 2

v=0
o=- 25678 753850 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=image 3456 udpt1 t38
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udpt1 t38
```

Step 21:

The terminating gateway sends back a success response:

```
200 2003 OK
```

Since the terminating gateway now has a RemoteConnectionDescriptor with "image/t38" as valid media, it can start exchanging T.38 with the originating gateway.

Steps 22, 23:

When the fax ends, a "t38(stop)" event is generated, which is notified to the Call Agent:

```
NTFY 2501 ds/ds1-1/2@gw-t.example.net MGCP 1.0
O: t38(stop)
X: 21
```

Step 24:

The Call Agent acknowledges the Notify command:

```
200 2501 OK
```

The fax call is now over. The Call Agent may now decide to change back to a voice codec, delete the connection, or do something different.

3.3. Interaction with SIP Endpoints

In this example, we show interaction with a SIP endpoint that does not support the RFC 3407 [RFC3407] capability descriptors. To accommodate such endpoints, the T.38 loose mode is being used (at the risk of initiating T.38 to an endpoint that does not support it). Once again, the originating fax does not generate CNG tone.

#	GW-o	CA-o	SIP-UA-t	fax
1		<- CRCX		
2	200(sdp-o)	->		
3		INVITE(sdp-o)	->	
4			<- 200(sdp-t)	
5			ACK	
6	<- 200	MDCX(sdp-t)		
7		->		
8				<- ANS/ T.30 CED
9				<- V.21 fax preamble
10			<- INVITE(sdp-t2)	
11	<- 200(sdp-o2)	MDCX(sdp-t2)		
12		->		
13		200(sdp-o2)	->	
14			<- ACK	
15	V.21 fax -> preamble			
16	NTFY(t38 start)	->		
17		<- 200		
18		<- RQNT(T38 event)		
19	200	->		
20				(fax ends)
21			<- BYE	
22			200	
23	NTFY(t38 stop)	->		
24		<- 200		

Step 1:

The Call Agent issues a CreateConnection command to the gateway, instructing it to use PCMU media encoding and to use the loose Call Agent controlled T.38 procedure. Consequently, the Call Agent asks the gateway to notify it of the "t38" event:

```
CRCX 1000 ds/ds1-1/1@gw-o.example.net MGCP 1.0
C: 1
L: a:PCMU, fxr/fx:t38-loose
M: recvonly
R: fxr/t38
X: 1
```

Step 2:

The gateway acknowledges the command and includes SDP with codec information and RFC 3407 [RFC3407] capability information:

```
200 1000 OK
I:1

v=0
o=- 25678 753849 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=audio 3456 RTP/AVP 0
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38
```

Step 3:

The originating SIP User Agent (UA) sends a SIP INVITE message with the SDP to the terminating Call Agent (not all SIP details shown here):

```
INVITE sip:bob@biloxi.example.com SIP/2.0
...
Content-Type: application/sdp
Content-Length: 167

v=0
o=- 25678 753849 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=audio 3456 RTP/AVP 0
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udptl t38
```

Step 4:

The terminating SIP User Agent sends back a SIP 200 OK response (not all SIP details shown) to the originating Call Agent:

```
SIP/2.0 200 OK
...
Content-Type: application/sdp
Content-Length: 100

v=0
o=- 25678 753849 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=audio 1296 RTP/AVP 0
```

Note that the terminating SIP User Agent does not use the RFC 3407 [RFC3407] capability descriptor to indicate support for (or lack of support for) T.38.

Step 5:

The originating Call Agent receives the SIP 200 response and sends a SIP ACK message to the terminating SIP UA.

Note that the Call Agent does not know whether the peer entity supports T.38. In order to figure this out, the Call Agent could send a SIP OPTIONS request to the terminating SIP UA, requesting it to return its capabilities (not shown). Note that this can of course be done towards any SIP peer, e.g., if the other side was a Call Agent speaking SIP it could be done there too.

Step 6:

The originating Call Agent in turns sends a ModifyConnection command to the originating gateway:

```
MDCX 1001 ds/ds1-1/1@gw-o.example.net MGCP 1.0
C: 1
I: 1
M: sendrecv

v=0
o=- 25678 753849 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=audio 1296 RTP/AVP 0
```

The ModifyConnection command does not repeat the LocalConnectionOptions sent previously. As far as fax handling is concerned, the gateway therefore attempts to continue using the current fax handling procedure, i.e., loose Call Agent controlled T.38. The T.38 loose procedure can always be supported, and hence a switch to T.38 will be attempted if the originating gateway detects a fax call.

Step 7:

The gateway acknowledges the command. At this point, a call is established using PCMU encoding, and if a fax call is detected, the Call Agent controlled T.38 procedure will be initiated.

Steps 8, 9:

A fax call now occurs. The T.30 CED tone (a.k.a. V.25 ANS) is sent--in this case, it is simply passed through the current PCMU encoding. Since both fax and modem calls can start with this sequence, it is not possible to determine that this is a fax call until step 9, where the V.21 fax preamble is detected.

Step 10:

The terminating SIP UA does in fact support T.38 and, upon detecting the fax call, attempts to change to T.38. Consequently, it sends a re-INVITE to the originating Call Agent with an updated SDP indicating a switch to T.38.

```
INVITE sip:ca@ca-o.example.net SIP/2.0
...
Content-Type: application/sdp
Content-Length: 100

v=0
o=- 25678 753850 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=image 1296 udpt1 t38
```

Step 11:

The originating Call Agent then sends a ModifyConnection command to the originating gateway:

```
MDCX 1003 ds/ds1-1/1@gw-o.example.net MGCP 1.0
C: 1
I: 1

v=0
o=- 25678 753850 IN IP4 192.0.2.2
s=-
c=IN IP4 192.0.2.2
t=0 0
m=image 1296 udpt1 t38
```

Step 12:

The originating gateway changes to T.38 and sends back a success response with updated SDP:

```
200 1003 OK

v=0
o=- 25678 753850 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=image 3456 udpt1 t38
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udpt1 t38
```

Step 13:

The originating Call Agent sends a SIP 200 OK response with the updated SDP to the terminating SIP User Agent:

```
SIP/2.0 200 OK
...
Content-Type: application/sdp
Content-Length: 167

v=0
o=- 25678 753850 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
m=image 3456 udpt1 t38
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 0 18
a=cdsc: 3 image udpt1 t38
```

Step 14:

The terminating SIP User Agent receives the SIP 200 and sends a SIP ACK.

Since the terminating SIP User Agent now has a RemoteConnectionDescriptor with "image/t38" as valid media, it can start exchanging T.38 with the originating gateway (and vice versa).

Steps 15, 16:

The originating endpoint detects V.21 fax preamble. Even though the endpoint is already using "image/t38" for media, it generates a "t38(start)" event and notifies the Call Agent.

```
NTFY 3500 ds/ds1-1/1@gw-o.example.net MGCP 1.0
O: fxr/t38(start)
X: 1
```

Steps 17, 18:

The Call Agent acknowledges the Notify command and issues a new (piggybacked) request for notification of the T38 event.

```
200 3500 OK
.
RQNT 1004 ds/ds1-1/1@gw-o.example.net MGCP 1.0
R: fxr/t38
X: 2
```

Step 19:

The gateway acknowledges the command.

```
200 1004 OK
```

Steps 20-22:

When the fax ends, the terminating SIP UA decides to tear down the call and hence sends a SIP BYE message, which the Call Agent responds to with a SIP 200.

Step 23:

The originating endpoint also generates a "t38(stop)" event, which is notified to the Call Agent:

```
NTFY 3502 ds/ds1-1/1@gw-o.example.net MGCP 1.0 O: t38(stop) X: 2
```

Step 24:

The Call Agent acknowledges the Notify command:

```
200 3502 OK
```

The fax call is now over. The Call Agent may now decide to change back to a voice codec, delete the connection, or do something different.

4. Security Considerations

The MGCP fax package itself is not known to introduce any new security concerns. However, implementers should note that T.38 media is currently transported over UDP (UDPTL) or TCP in the clear and without any integrity protection. If for example security services are in place to protect RTP media streams, these will thus not be in effect for the T.38 media stream. If such lack of security is a concern, the fax LocalConnectionOptions allowing T.38 in this package SHOULD NOT be used, i.e., the "off" (or a new secure extension) fax LocalConnectionOption should be used.

5. IANA Considerations

IANA has registered the following MGCP package:

Package Title	Name	Version
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Fax	FXR	0

6. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.
- [RFC3435] Andreasen, F. and B. Foster, "Media Gateway Control Protocol (MGCP) Version 1.0", RFC 3435, January 2003.
- [T38] ITU-T Recommendation T.38, "Procedures for real-time Group 3 facsimile communication over IP networks", March 2002.
- [RFC3407] Andreasen, F., "Session Description Protocol (SDP) Simple Capability Declaration", RFC 3407, October 2002.

7. Informative References

- [T30] ITU-T Recommendation T.30, "Procedures for document facsimile transmission in the general switched telephone network", July 2003.
- [RFC3261] Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., Handley, M., and E. Schooler, "SIP: Session Initiation Protocol", RFC 3261, June 2002.
- [RFC3264] Rosenberg, J. and H. Schulzrinne, "An Offer/Answer Model with Session Description Protocol (SDP)", RFC 3264, June 2002.

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