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Media Gateway Control Protocol (MGCP) Voiceband Data (VBD) Package and General-Purpose Media Descriptor Parameter Package

Abstract

This document defines Media Gateway Control Protocol (MGCP) packages that enable a Call Agent to authorize and monitor the transition of a connection to and from Voiceband Data (VBD) with or without redundancy and FEC (forward error correction). Although the focus is on VBD, the General-Purpose Media Descriptor Parameter package can be used to authorize other modes of operation, not relevant to VBD, for a particular codec. In addition to defining these new packages, this document describes the use of the Media Format Parameter package and Fax package with VBD, redundancy, and FEC.

Status of This Memo

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Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc6498.

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1. Applicability Statement

This document defines a mechanism that requires media stream integrity protection. The document specifies different alternative mechanisms but does not choose one of them as mandatory-to-implement. Consequently, the use of this specification is only suitable in environments that specify and use at least one of these alternative mechanisms. Please see the Security Considerations section for further details.

2. Introduction

The term Voiceband Data (or simply VBD) refers to the use of a suitable voiceband codec (commonly G.711u or G.711a) for the transport of data payloads using RTP as defined in RFC 3550 [RFC3550]. This document defines Media Gateway Control Protocol (MGCP) [RFC3435] packages that enable a Call Agent to authorize and monitor the transition of a connection to and from VBD with or without redundancy [RFC2198] and FEC (forward error correction) [RFC5109].

There are a number of different VBD procedures. These procedures vary in terms of how the transition to and from VBD is coordinated end to end. Some coordination techniques are mutually negotiated by the two gateways using the Session Description Protocol (SDP) [RFC4566]. These coordination techniques include

- ITU-T Recommendation V.150.1 State Signaling Event (SSE) [V1501]

- ITU-T Recommendation V.152 Payload Type Switching [V152]

Other coordination techniques are not negotiated. For example, the detection of fax, modem, and text tones in the direction from the IP to the General Switched Telephone Network (GSTN) may result in a switch to VBD or a change (e.g., disable echo cancellation) to the gateway controlled VBD procedure already in place. The IP-side detected tone serves as both a VBD stimulus and a coordination technique.

RFC 4733 [RFC4733] and RFC 4734 [RFC4734] can be used to convey fax and modem events and tones. As with IP-side tone detection, the telephone event may serve as both a VBD stimulus and a coordination technique. Note that while the use of RFC 4733 and RFC 4734 to convey fax and modem events and tones is negotiated, the use of RFC 4733 and RFC 4734 as a gateway VBD coordination technique (at present) is not.

The Voiceband Data (VBD) package is defined to support all VBD procedures. This document does not address the relative merits of different procedures nor does it advocate one procedure over another.

We will use the term VBD to refer to Voiceband Data in general. In referring to VBD in the context of the package, we will use the term VBD package. We use the term "audio" (with double quotes) to refer to the IANA media type. We use the term audio (without double quotes) to refer to the use of the "audio" media type for (most commonly) voice.

A package is defined for the General-Purpose Media Descriptor Parameter [V152]. In the context of VBD, the General-Purpose Media Descriptor Parameter (GPMD) package is used to authorize the negotiation of a particular codec for use with VBD. The General-Purpose Media Descriptor Parameter is "general" in nature and may be used in applications other than VBD.

The Media Format Parameter (FM) package [RFC3660] describes the use of the standard audio MIME subtype "RED" in conjunction with the "fmtp" LocalConnectionOption in order to authorize the negotiation of redundancy [RFC2198], to identify the levels of redundancy and the

media format associated with each redundancy level. This document will further explore the use of the FM package with VBD and redundancy.

The VBD package is intended to complement the MGCP Fax (FXR) package [RFC5347]. This document will explore the use of the FXR package with VBD.

The VBD package definition is provided in Section 4. The GPMD package definition is provided in Section 5. In Section 6, we discuss the use of the FM package with VBD and redundancy. In Section 7, we discuss the use of the FM package with VBD and FEC. In Section 8, we discuss the use of the FXR package with VBD. In Section 9, we provide two call flow examples showing how to use the VBD and GPMD packages. Security considerations are found in Section 10, followed by the IANA considerations (Section 11) and references.

3. Terminology

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

4. Voiceband Data Package Definition

This package is defined for Voiceband Data (VBD). The package defines new events as detailed below.

Package Name: VBD

Package Version: 0

4.1. Events and Signals

The following events are defined in support of the above:

Symbol	Definition	R	S	Duration
gwvbd	Gateway Controlled VBD	x		
nopvbd	No Negotiated Procedure for VBD	x		

This is standard MGCP package format as defined in Section 6.6 of RFC 3435 [RFC3435]. The definitions of the individual events are provided in the following subsections.

4.1.1. Gateway Controlled Voiceband Data

The gwvbd procedure can be used by the gateway to control and decide how to handle VBD calls without Call Agent involvement. The "Gateway Controlled Voiceband Data" (or simply "gwvbd") event occurs when a gwvbd procedure has been negotiated and VBD stimulus is detected. The "gwvbd" event may occur when the gwvbd procedure is updated (e.g., upon detecting new stimulus) and when the procedure fails. The "gwvbd" event occurs when the gwvbd procedure ends. The gwvbd procedure MUST be negotiated with the other side by passing and recognizing relevant parameters via the LocalConnectionDescriptor and RemoteConnectionDescriptor.

The following recommendations from MGCP [RFC3435] apply.

In this section, we provide a formal description of the protocol syntax, using ABNF as defined in "Augmented BNF for Syntax Specifications: ABNF" [RFC5234]. The syntax makes use of the core rules defined in Appendix B.1 of [RFC5234], which are not included here. Furthermore, the syntax follows the case-sensitivity rules of [RFC5234], i.e., MGCP is case-insensitive (but SDP is not). It should be noted that ABNF does not provide for implicit specification of linear white space, and MGCP messages MUST thus follow the explicit linear white space rules provided in the grammar below. However, in line with general robustness principles, implementers are strongly encouraged to tolerate additional linear white space in messages received.

The RequestedEvent parameter is encoded as

```
GwVbdReqEvent = "gwvbd"
```

The ObservedEvent parameter is encoded as

```
GwVbdObsEvent = GwVbdObsEventStart / GwVbdObsEventUpdate /
                GwVbdObsEventStop / GwVbdObsEventFailure

GwVbdObsEventStart   = "gwvbd(start" Rc [Codec] [Coord] [Dir] ")"
GwVbdObsEventUpdate  = "gwvbd(update" Rc [Codec] [Dir] ")"
GwVbdObsEventStop    = "gwvbd(stop" [Rc] [Codec] ")"
GwVbdObsEventFailure = "gwvbd(failure" [Rc] [Codec] ")"
```

```
Codec = "," *WSP "codec=" CodecString
CodecString = (ALPHA / DIGIT) *(ALPHA / DIGIT / "-" / "_" /
                "." / "/")
Coord = "," *WSP "coord=" CoordinationTechnique
CoordinationTechnique = "v152ptsw" / "v150fw"
Rc = "," *WSP "rc=" ReasonCode
ReasonCode = 1*(ALPHA / DIGIT / "-" / "_" / "." / "/")
             ; Refer to the values listed in the tables below.
Dir = "," *WSP "dir=" Direction
Direction = "GstnToIp" / "IpToGstn"
```

ABNF does not provide for position-independent parameters. The "rc", "codec", "coord", and "dir" parameters, if present, MUST appear in the relative order shown.

The "start", "update", "stop", and "failure" ObservedEvent parameters are defined as follows:

1) VBD Start (start)

   The gwvbd procedure was initiated. The Call Agent SHOULD refrain from issuing media handling instructions to the gateway until either a "gwvbd(stop)" or "gwvbd(failure)" event is generated. One and only one "gwvbd(stop)" or "gwvbd(failure)" event is generated corresponding to each "gwvbd(start)" event.

2) VBD Update (update)

   The gwvbd procedure was updated. The "gwvbd(update)" event MUST only be generated after a "gwvbd(start)" event and before a "gwvbd(stop)" or "gwvbd(failure)" event.

3) VBD Stop (stop)

   The gwvbd procedure ended, and the gateway did not detect any errors. Note that this does not necessarily imply a successful fax, modem, or text transmission. It merely indicates that the gwvbd procedure has ended and the procedure itself did not encounter any errors. The "stop" parameter may correspond to a change from VBD to a non-VBD "audio" codec or from VBD to another media type such as "image" or "text". This change may be under Call Agent or gateway control. For example, the gateway may coordinate the switch from VBD to "image/t38" through the exchange of SSEs [T38] [V152]. For an example involving Call Agent control, refer to the "MC" Reason Code. In both examples, the gwvbd procedure ends with the media change.

4) VBD Failure (failure)

The gwvbd procedure ended abnormally. Some kind of problem was encountered in the gwvbd procedure, and the procedure ended.

When the "gwvbd" event is reported, exactly one of the "start", "update", "stop", or "failure" parameters MUST be present and MUST be the first parameter supplied.

The "rc", "codec", "coord", and "dir" ObservedEvent parameters are defined as follows:

1) Reason Code (rc=<ReasonCode>)

With the "start" and "update" parameters, the reason for triggering the switch/change to VBD. With the "stop" and "failure" parameters, the reason for triggering the switch from VBD. The Reason Codes in the following table, which are based on the ITU-T Fax/Textphone/Modem Tones Detection package [H2482], ITU-T V.150.1 Amendment 1 [V1501A1], and ITU-T V.152 [V152], may be used with the "start" and "update" parameters:

ReasonCode	Description
CNG	T.30 fax calling
V21flag	V.21 tone and flags for fax answering
CIV18	V.8 CI with V.18 call function
XCI	V.18 XCI
V18txp	V.18 txp
Belltone	Bell 103 carrier, high- or low-frequency channel (ITU-T Recommendation V.18)
Baudot	Baudot initial tone and character (ITU-T Recommendation V.18)
Edt	EDT initial tone and character (ITU-T Recommendation V.18)
CIdata	V.8 CI with any data call function
CT	V.25 calling tone
CIfax	V.8 CI with fax call function
V21tone	V.21 carrier, high- or low-frequency channel
V23tone	V.23 carrier, high- or low-frequency channel
V8bis	V.8 bis modem handshaking signal
ANS	V.25 ANS, equivalent to T.30 CED from answering terminal
/ANS	V.25 ANS with periodic phase reversals
ANSam	V.8 ANSam
/ANSam	V.8 ANSam with periodic phase reversals
CMFax	V.8 CM sequence indicating fax call function
JMFax	V.8 JM sequence indicating fax call function
CMData	V.8 CM sequence indicating unspecified data call function
JMData	V.8 JM sequence indicating unspecified data call function
CMText	V.8 CM sequence indicating text call function
JMText	V.8 JM sequence indicating text call function
PTSW	Payload type switch as defined in V.152

For solutions involving textphones using a modulation with interspersed text and speech on the same "channel", such as Baudot and EDT, the Call Agent SHOULD interpret the ReasonCode parameter as part of the "vbd/gwvbd(start)" event in order to differentiate between fax, modem, and text. In the case of interspersed text and speech, the Call Agent SHOULD remove the notification request for "vbd/gwvbd" upon receiving the "vbd/gwvbd(start)" event in order to avoid large numbers of notifications.

For example,

```
vbd/gwvbd(start, rc=Baudot)
```

With a ReasonCode of "PTSW", the Call Agent cannot differentiate text from fax/modem. In this case, the Call Agent SHOULD adopt a policy that guards against large numbers of notifications. We consider several such policies.

The Call Agent MAY remove the notification request for "vbd/gwvbd" upon receiving the "vbd/gwvbd(start, rc=PTSW)" event. With this policy, "update", "stop", and "failure" notifications will not be generated with text AND fax/modem.

The Call Agent MAY wait for a subsequent "vbd/gwvbd(update)" event that differentiates text from fax/modem. If the ReasonCode indicates interspersed text and speech, the Call Agent SHOULD remove the notification request for "vbd/gwvbd". For example,

```
vbd/gwvbd(update, rc=Edt)
```

The Call Agent MAY remove the notification request for "vbd/gwvbd" upon receiving a "vbd/gwvbd(stop)" event without having differentiated between text and fax/modem.

The Call Agent MAY remove the notification request for "vbd/gwvbd" after having received a number of "vbd/gwvbd(start)" events without having differentiated between text and fax/modem. The specific number of events after which the notification request is removed is considered an implementation detail outside the scope of this specification.

Reason Codes applicable with the "stop" parameter are listed below:

ReasonCode	Description
SIL	Bidirectional silence
Voice	Voice signals
PTSW	Payload type switch as defined in V.152
MC	Media change

The "MC" Reason Code indicates that the media type has changed from "audio" (to "image", "text", ...) or the "audio" media format has changed from a VBD codec (for a reason other than "PTSW"). For example, the gwvbd procedure may be initiated upon detecting called terminal identification (CED). Subsequently, the Call Agent controlled T.38 procedure of the MGCP Fax (FXR) package [RFC5347] may be initiated upon detecting V.21 flags. Upon receipt of a "t38(start)" event, the Call Agent will instruct the

gateway to switch from VBD to T.38 through the use of a ModifyConnection command involving a LocalConnectionOption encoding method of "L:a:image/t38" and/or a RemoteConnectionDescriptor with an "image/t38" media description. This stops the gwvbd procedure. There is no specific interdependency between the VBD package and the FXR package (or any other package). The gwvbd procedure is stopped as a consequence of the media change, not as a direct consequence of the T.38 procedure being initiated. Note that in this situation the "t38(start)" event will be sent before the "gwvbd(stop)" event. The Call Agent MAY choose to infer that the gwvbd procedure has ended upon receiving the "t38(start)" event and disable the notification of the "gwvbd" event. Refer to the example call flow in Section 9.2.

Reason Codes applicable with the "failure" parameter:

ReasonCode	Description
TO	Indicates that a timeout has occurred

The list of Reason Codes may be extended to include values with meaning mutually understood between the gateway and the Call Agent. Obviously, the use of extended values MUST be a provisionable option on the gateway in order to ensure interoperability with the Call Agent.

2) Codec String (codec=<CodecString>)

With the "start" and "update" parameters, the codec parameter describes the MIME type associated with the switch/change to VBD (e.g., "audio/RED", "audio/PCMU", "audio/PCMA", "audio/G726-32", "audio/clearmode", ...). With the "stop" and "failure" parameters, the codec parameter describes the MIME type associated with the switch from VBD (e.g., "audio/G729", "image/t38", "text/t140", "audio/v150mr", ...). These strings should be full MIME types as listed in http://www.iana.org/assignments/media-types.

3) Coordination Technique (coord=<CoordinationTechnique>)

The technique used to coordinate the transition to and from VBD with the remote endpoint. The coordination techniques are summarized in the following table:

CoordinationTechnique	Description
v152ptsw	V.152 Payload Type Switching
v150fw	V.150.1 SSE

With the "v152ptsw" coordination technique, payload type switching [V152] is used to coordinate the transition to and from VBD.

With the "v150fw" coordination technique, state signaling events [V1501] are used to coordinate the transition to and from VBD.

The list of coordination techniques may be extended to include values with meaning mutually understood between the gateway and the Call Agent. Obviously, the use of extended values MUST be a provisionable option on the gateway in order to ensure interoperability with the Call Agent.

4) Direction of Stimulus (dir=<Direction>)

With the "start" and "update" parameters, the "dir" parameter describes the direction of the stimulus that resulted in the switch/change to VBD.

Direction	Description
GstnToIp	Stimulus detected in the direction from the GSTN to IP network, including fax, modem, and text tones.
IpToGstn	Stimulus detected in the direction from the IP to GSTN network, including fax, modem, and text tones (e.g., IP-side tone detection); RTP packet with VBD payload type (e.g., V.152 or V.150.1).

Call Agents and gateways MUST implement the "start" and "stop" parameters and MAY implement the "update" and "failure" parameters. Call Agents and gateways MAY implement the "coord", "codec", and "dir" parameters. Call Agents MAY, and gateways MUST, implement the "rc" parameter in conjunction with the "start" and "update" parameters. Call Agents and gateways MAY implement the "rc" parameter in conjunction with the "stop" and "failure" parameters. A Call Agent MUST ignore all unknown ObservedEvent parameters, including parameters that are defined as part of this specification and not implemented.

4.1.1.1. Gateway Controlled Voiceband Data Examples

The following examples illustrate the encoding of the "gwvbd(start)" event:

```
O: vbd/gwvbd(start, rc=ANS)
O: vbd/gwvbd(start, rc=ANS, codec=audio/PCMU, coord=v152ptsw)
O: vbd/gwvbd(start, rc=PTSW, codec=audio/RED)
```

The following example illustrates the encoding of the "gwvbd(update)" event:

```
O: vbd/gwvbd(update, rc=/ANSam, dir=IpToGstn)
```

The following examples illustrate the encoding of the "gwvbd(stop)" event:

```
O: vbd/gwvbd(stop)
O: vbd/gwvbd(stop, rc=SIL, codec=audio/G729)
O: vbd/gwvbd(stop, rc=MC, codec=image/t38)
```

The following examples illustrate the encoding of the "gwvbd(failure)" event:

```
O: vbd/gwvbd(failure, codec=audio/G729)
O: vbd/gwvbd(failure, rc=TO, codec=audio/G729)
```

4.1.2. No Negotiated Procedure for Voiceband Data

The "No Negotiated Procedure for Voiceband Data" (or simply "nopvbd") event occurs when a VBD procedure has not been negotiated and VBD stimulus is detected. The "nopvbd" event may occur when the procedure is updated (e.g., upon detecting new stimulus), when the procedure ends, and when the procedure fails. Even though a procedure was not negotiated, a VBD handling procedure MAY still be in place locally on the endpoint, as described further below.

The nopvbd procedure MAY involve VBD handling including, but not limited to, adjusting gain and jitter, disabling voice activity detection, and DC offset filters. The nopvbd procedure MAY involve switching to another codec. The Call Agent MAY have to issue further commands in response to the "nopvbd" event in order to ensure a successful VBD call.

As with the "gwvbd" event, the same recommendations from MGCP [RFC3435] regarding ABNF, general robustness principles, and white space apply.

The RequestedEvent parameter is encoded as

```
NopVbdReqEvent = "nopvbd"
```

The ObservedEvent parameter is encoded as

```
NopVbdObsEvent = NopVbdObsEventStart / NopVbdObsEventUpdate /
                 NopVbdObsEventStop / NopVbdObsEventFailure

NopVbdObsEventStart   = "nopvbd(start" Rc [Codec] [Dir] ")"
NopVbdObsEventUpdate  = "nopvbd(update" Rc [Codec] [Dir] ")"
NopVbdObsEventStop    = "nopvbd(stop" [Rc] [Codec] ")"
NopVbdObsEventFailure = "nopvbd(failure" [Rc] [Codec] ")"
```

The following ABNF notation is common with the "gwvbd" ObservedEvent parameter:

```
Codec = "," *WSP "codec=" CodecString
CodecString = (ALPHA / DIGIT) *(ALPHA / DIGIT / "-" / "_" /
               "." / "/")
Rc = "," *WSP "rc=" ReasonCode
ReasonCode = 1*(ALPHA / DIGIT / "-" / "_" / "." / "/")
             ; Refer to the values listed in the tables above.
Dir = "," *WSP "dir=" Direction
Direction = "GstnToIp" / "IpToGstn"
```

ABNF does not provide for position-independent parameters. The "rc", "codec", and "dir" parameters, if present, MUST appear in the relative order shown.

The "start", "update", "stop", and "failure" ObservedEvent parameters are defined as follows:

1) VBD Start(start)

   The nopvbd procedure was initiated. The Call Agent may have to issue further commands in order to ensure a successful VBD call (e.g., switch to another codec). At most one "nopvbd(stop)" or "nopvbd(failure)" event MAY be generated corresponding to each "nopvbd(start)" event. The Call Agent MAY need to infer that the nopvbd procedure has ended.

2) VBD Update (update)

   The nopvbd procedure was updated. The "nopvbd(update)" event MUST only be generated after a "nopvbd(start)" event and before a "nopvbd(stop)" or "nopvbd(failure)" event.

3) VBD Stop (stop)

   The nopvbd procedure ended, and the gateway did not detect any errors. Note that this does not necessarily imply a successful fax, modem, or text transmission. It merely indicates that the nopvbd procedure has ended and the procedure itself did not encounter any errors. Refer to the definition of the "stop" parameter from the "gwvbd" event in Section 4.1.1 for additional information.

4) VBD Failure (failure)

   The nopvbd procedure ended abnormally. Some kind of problem was encountered in the nopvbd procedure, and the procedure ended.

Call Agents and gateways MUST implement the "start" parameter and MAY implement the "update", "stop", and "failure" parameters. Call Agents MAY, and gateways MUST, implement the "rc" parameter in conjunction with the "start" and "update" parameters. Call Agents and gateways MAY implement the "rc" parameter in conjunction with the "stop" and "failure" parameters. A Call Agent MUST ignore all unknown ObservedEvent parameters including parameters that are defined as part of this specification and not implemented.

The definitions of the "rc", "codec", and "dir" ObservedEvent parameters are taken from the "gwvbd" event.

As with the "gwvbd" event, the same recommendations regarding interspersed text and speech apply.

4.1.2.1. No Negotiated Procedure for Voiceband Data Examples

The following examples illustrate the encoding of the "nopvbd(start)" event:

```
O: vbd/nopvbd(start, rc=ANS)
O: vbd/nopvbd(start, rc=ANS, codec=audio/PCMU)
```

The following example illustrates the encoding of the "nopvbd(update)" event:

```
O: vbd/nopvbd(update, rc=/ANSam, dir=IpToGstn)
```

The following examples illustrate the encoding of the "nopvbd(stop)" event:

```
O: vbd/nopvbd(stop)
O: vbd/nopvbd(stop, rc=SIL, codec=audio/G729)
O: vbd/nopvbd(stop, rc=MC, codec=image/t38)
```

The following examples illustrate the encoding of the "nopvbd(failure)" event:

```
O: vbd/nopvbd(failure, codec=audio/G729)
O: vbd/nopvbd(failure, rc=TO, codec=audio/G729)
```

5. General-Purpose Media Descriptor Parameter Package Definition

This package is defined for the General-Purpose Media Descriptor Parameter [V152]. The package defines a new LocalConnectionOption as detailed below.

```
Package Name:        GPMD
Package Version:     0
```

5.1. LocalConnectionOptions

The following new LocalConnectionOptions field is defined in support of the above:

Symbol	Definition
gpmd	General-Purpose Media Descriptor Parameter

The definition of the LocalConnectionOption is provided in the following subsection.

5.1.1. General-Purpose Media Descriptor Parameter

The General-Purpose Media Descriptor Parameter LocalConnectionOption is similar to the "gpmd" SDP [RFC4566] attribute defined in ITU-T Recommendation V.152 [V152] and is applicable to all of the same media formats that the corresponding SDP "gpmd" attribute could be used with.

The General-Purpose Media Descriptor Parameter is encoded as the keyword "gpmd" or "o-gpmd", followed by a colon and a quoted string beginning with the media format name (MIME subtype only) followed by a space, followed by the media format parameters associated with that media format:

```
gpmd/gpmd:"<format> <parameter list>"
```

For simplicity, we will use the terms "codec" and "media format" interchangeably in the following. Multiple media formats may be indicated by either repeating the "gpmd" LocalConnectionOption multiple times, such as

```
L: a:codec1;codec2, gpmd/gpmd:"codec1 parameterX",
                    gpmd/gpmd:"codec2 parameterY"
```

or alternatively by having a single "gpmd" keyword followed by a colon, and a semicolon-separated list of quoted strings for each General-Purpose Media Descriptor Parameter, as in

```
L: a:codec1;codec2, gpmd/gpmd:"codec1 parameterX";
                                "codec2 parameterY"
```

The two formats may be mixed:

```
L: a:codec1;codec2;codec3, gpmd/gpmd:"codec1 parameterX",
                           gpmd/gpmd:"codec2 parameterY";
                                     "codec3 parameterZ"
```

The carriage returns above are included for formatting reasons only and are not permissible in a real implementation. This holds true for all of the examples in this document.

If it is possible for the same codec to be requested with and without the "gpmd" parameter, the following could result:

```
L: a:codec1;codec1, gpmd/gpmd:"codec1 parameterX"
```

However, it would not be clear whether the "gpmd" parameter was to be applied to the first or the second occurrence of the codec. The problem is that codec ordering is important (i.e., codecs are listed in preferred order), and the above syntax does not provide a way to indicate whether "parameterX" is preferred (i.e., associated with the first "codec1") or not (i.e., associated with the second "codec1"). In order to resolve this dilemma, the codec in the "gpmd" media format is followed by a colon and an <order>, where <order> is a number from one to N for occurrences of the same codec in the codec list. For example,

```
L:a:codec1;codec1, gpmd/gpmd:"codec1:2 parameterX"
```

indicates that "parameterX" is associated with the second instance of "codec1" in the "a:codec1;codec1" list. If an invalid instance number is supplied (e.g., instance 3 where there are only two instances), then error code 524 -- inconsistency in local connection options -- will be returned. In the absence of an <order>, the first instance is assumed.

Prepending "gpmd" with the string "o-" (i.e., "o-gpmd") indicates that the parameter is optional. In that case, the gateway may decide not to use the "gpmd" parameter specified, or only use it in part.

If the "gpmd" LocalConnectionOption parameter is not optional (i.e., does not have "o-" in front of it), and the LocalConnectionOption parameter value is either not recognized or not supported, then the associated codec is considered "not supported".

When auditing capabilities, the "gpmd" LocalConnectionOption parameter MUST be returned with a semicolon-separated list of supported formats and/or multiple independent "gpmd" parameters, as in

```
A: a:codec1;codec2, gpmd/gpmd:"codec1 parameterX";
                               "codec2 parameterY"
```

or

```
A: a:codec1;codec1, gpmd/gpmd:"codec1 parameterX"
```

One example uses the General-Purpose Media Descriptor Parameter LocalConnectionOption in conjunction with gateway controlled Voiceband Data (or simply VBD) using payload type switching [V152]. In the context of VBD, the <format> must be an RTP/AVP payload type. The <parameter list> is a semicolon-separated list of "parameter=value" pairs:

```
L: a:codec1, gpmd/gpmd:"codec1 parameterX=ValueA;parameterY=ValueB"
```

In the example below, G.729 is an audio codec and G.711u is a VBD codec:

```
L: a:G729;PCMU, gpmd/gpmd:"PCMU vbd=yes"
```

The corresponding media description in the SDP as part of the connection request acknowledgment might look like

```
m=audio 12345 RTP/AVP 18 96
a=rtpmap:96 PCMU/8000
a=gpmd:96 vbd=yes
```

If a request is made to audit the capabilities of an endpoint, and the endpoint supports G.711u as both an audio and VBD codec, then the "gpmd" LocalConnectionOption parameter might look like

```
A: a:PCMU, p:10-40, e:on, s:on,
   m:sendonly;recvonly;sendrecv;inactive
A: a:PCMU, p:10-40, e:on, s:off,
   m:sendonly;recvonly;sendrecv;inactive,
   gpmd/gpmd:"PCMU vbd=yes"
```

Given that some parameters, e.g., silence suppression, are only compatible with G.711u as an audio codec, then the gateway MUST return different capability sets corresponding to audio and VBD.

If we combine V.152 and redundancy [RFC2198], an example LocalConnectionOption might look like the example below. In this example, G.729 is an audio codec and G.711u is a VBD codec with a redundancy level of one:

```
L: a:G729;RED;PCMU, gpmd/gpmd:"PCMU vbd=yes", fmtp:"RED PCMU/PCMU"
```

The corresponding media description in the SDP as part of the connection request acknowledgment might look like

```
m=audio 12345 RTP/AVP 18 96 97
a=rtpmap:96 RED/8000
a=fmtp:96 97/97
a=rtpmap:97 PCMU/8000
a=gpmd:97 vbd=yes
```

Refer to Section 6 for more examples involving V.152 and redundancy.

6. Use of Media Format Parameter Package with VBD and Redundancy

The MGCP Media Format Parameter (FM) package [RFC3660] in conjunction with the standard audio MIME subtype "RED" may be used by the Call Agent to authorize the negotiation of redundancy [RFC2198], to identify the levels of redundancy and the media format associated with each redundancy level. An example of this was demonstrated in Section 5.

The FM package states that the "fmtp" LocalConnectionOption MUST be returned when auditing capabilities. Applying this to VBD and redundancy might result in

```
A: a:PCMU, p:10-40, e:on, s:on,
   m:sendonly;recvonly;sendrecv;inactive
A: a:RED;PCMU, p:10-40, e:on, s:off,
   m:sendonly;recvonly;sendrecv;inactive,
   gpmd/gpmd:"PCMU vbd=yes",
   fmtp:"RED PCMU/PCMU"
```

The FM package defines "instance syntax", in which

```
L:a:codec1;codec1, fmtp:"codec1:2 formatX"
```

indicates that "formatX" is associated with the second instance of "codec1" in the "a:codec1;codec1" list. The examples in the FM package are limited to the use of the instance syntax in conjunction with the media format. We propose the use of the instance syntax in conjunction with the media format parameters

```
L:a:codec1;codec2;codec3;codec2, fmtp:"codec3 codec2:2/codec2:2"
```

Let's build on the example of Section 5. In the example below, G.729 is an audio codec, and G.711u is both an audio codec and a VBD codec with a redundancy level of one:

```
L: a:G729;PCMU;RED;PCMU, gpmd/gpmd:"PCMU:2 vbd=yes",
                         fmtp:"RED PCMU:2/PCMU:2"
```

The corresponding media description in the SDP as part of the connection request acknowledgment might look like

```
m=audio 12345 RTP/AVP 18 0 96 97
a=rtpmap:96 RED/8000
a=fmtp:96 97/97
a=rtpmap:97 PCMU/8000
a=gpmd:97 vbd=yes
```

Note that the relative preference of the LocalConnectionOption encoding methods is preserved in the "audio" media formats (i.e., payload types) as part of the media description. In this example, this reflects a preference for V.152 with redundancy versus without. No preference is inferred from the relative order of the different LocalConnectionOptions, namely "a", "gpmd/gpmd", and "fmtp".

A Call Agent can authorize the negotiation of audio codecs and VBD codecs involving different levels of redundancy. In the example below, G.711u is a VBD codec with a redundancy level of two (preferred) or one:

```
L: a:G729;RED;RED;PCMU, fmtp:"RED PCMU/PCMU/PCMU",
                        fmtp:"RED:2 PCMU/PCMU",
                        gpmd/gpmd:"PCMU vbd=yes"
```

The corresponding media description in the SDP as part of the connection request acknowledgment might look like

```
m=audio 12345 RTP/AVP 18 96 97 98
a=rtpmap:96 RED/8000
a=fmtp:96 98/98/98
a=rtpmap:97 RED/8000
a=fmtp:97 98/98
a=rtpmap:98 PCMU/8000
a=gpmd:98 vbd=yes
```

Redundancy can be applied to both audio codecs and VBD codecs. In the example below, G.729 is an audio codec with a redundancy level of two and G.711u is a VBD codec with a redundancy level of one:

```
L: a:RED;G729;RED;PCMU, fmtp:"RED G729/G729/G729",
                        fmtp:"RED:2 PCMU/PCMU",
                        gpmd/gpmd:"PCMU vbd=yes"
```

The corresponding media description in the SDP as part of the connection request acknowledgment might look like

```
m=audio 12345 RTP/AVP 96 18 97 98
a=rtpmap:96 RED/8000
a=fmtp:96 18/18/18
a=rtpmap:97 RED/8000
a=fmtp:97 98/98
a=rtpmap:98 PCMU/8000
a=gpmd:98 vbd=yes
```

7. Use of Media Format Parameter Package with VBD and FEC

A Call Agent may authorize the negotiation of forward error correction (FEC) [RFC5109] with the standard audio MIME subtype "parityfec":

```
L: a:PCMU;parityfec
```

By default, we assume that FEC packets are to be sent as a separate stream. The corresponding media description in the SDP as part of the connection request acknowledgment might look like

```
v=0
c=IN IP4 192.0.2.0
m=audio 49170 RTP/AVP 0 96
a=rtpmap:96 parityfec/8000
a=fmtp:96 49172 IN IP4 192.0.2.0
```

If FEC is to be sent as a secondary codec in the redundant codec payload format [RFC2198], we again leverage the MGCP Media Format Parameter (FM) package [RFC3660] in conjunction with the standard audio MIME subtype "RED":

```
L: a:G729;RED;PCMU;parityfec, gpmd/gpmd:"PCMU vbd=yes",
                              fmtp:"RED PCMU/parityfec"
```

The corresponding media description might look like

```
v=0
c=IN IP4 192.0.2.0
m=audio 49170 RTP/AVP 18 96 97 98
a=rtpmap:96 RED/8000
a=fmtp:96 97/98
a=rtpmap:97 PCMU/8000
a=gpmd:97 vbd=yes
a=rtpmap:98 parityfec/8000
```

The FM package states that the "fmtp" LocalConnectionOption MUST be returned when auditing capabilities. Applying this to VBD, redundancy and FEC might result in

```
A: a:PCMU, p:10-40, e:on, s:on,
   m:sendonly;recvonly;sendrecv;inactive
A: a:RED;PCMU;parityfec, p:10-40, e:on, s:off,
   m:sendonly;recvonly;sendrecv;inactive,
   gpmd/gpmd:"PCMU vbd=yes",
   fmtp:"RED PCMU/parityfec"
```

8. Use of Fax Package with VBD

The MGCP Fax (FXR) package [RFC5347] is used by a Call Agent to authorize fax handling, including Call Agent controlled T.38 and gateway procedures such as V.152. With the FXR package, VBD falls into one of two categories: "special fax handling" as part of the gateway procedure (resulting in the "gwfax" event), or "no special fax handling" as part of the gateway and Off procedures (resulting in the "nopfax" event). In order for a VBD procedure to fall into the "special fax handling" category, support for it MUST be negotiated with the other side by passing and recognizing relevant parameters via the LocalConnectionDescriptor and RemoteConnectionDescriptor.

A gateway controlled VBD procedure such as V.152 MUST fall into the category of gateway controlled mode involving "special fax handling". The resulting "gwfax" event is what informs the Call Agent to refrain from issuing media handling instructions that could otherwise have a negative impact on the gateway procedure.

Consider the following example (with shorthand SDP notation):

```
CRCX 2000 ds/ds1-1/2@gw-t.whatever.net MGCP 1.0
C: 1
M: sendrecv
L: a:G729;PCMU, gpmd/gpmd:"PCMU vbd=yes", fxr/fx:t38;gw
X: 1
R: fxr/t38, fxr/gwfax, fxr/nopfax

v=0
c=IN IP4 192.0.2.1
m=audio 3456 RTP/AVP 18 96
a=rtpmap:96 PCMU/8000
a=gpmd:96 vbd=yes

200 2000 OK
I: 1

v=0
c=IN IP4 192.0.2.2
m=audio 1296 RTP/AVP 18 96
a=rtpmap:96 PCMU/8000
a=gpmd:96 vbd=yes
```

The RemoteConnectionDescriptor does not indicate support for "image/t38" as a latent capability [RFC3407]. Consequently, the gateway will not initiate the T.38 strict fax procedure, "t38", upon detecting fax stimulus (i.e., CNG, V.21 flags, etc.). However, the two endpoints did successfully negotiate a gateway controlled VBD procedure (e.g., V.152); therefore, a gateway controlled mode involving "special fax handling" is used. The "gwfax(start)" event will be generated upon detecting VBD (including fax) stimulus.

A Call Agent can express a preference for a gateway procedure involving "special fax handling" over a T.38 procedure (strict or loose). For example,

```
L: fxr/fx:gw;t38
```

and

```
L: fxr/fx:gw;t38-loose
```

However, with the existing syntax of the FXR package, a Call Agent cannot express a preference for one gateway procedure over another, each with possibly different preferences relative to a T.38 procedure.

The FXR package allows a gateway to implement additional fax handling parameters. We define just such a parameter by qualifying the existing "gw" parameter with a list of one or more MIME types:

```
Gateway  = "gw[" mimeType 0*("|" mimeType) "]"
mimeType = mimeMediaType "/" mimeSubType
; mimeMediaType and mimeSubType from
;   http://www.iana.org/assignments/media-types/
```

By qualifying the "gw" parameter with a list of MIME types, we narrow the scope of the gateway procedure. Consider the following examples in which the Call Agent authorizes the use of a gateway controlled fax handling procedure:

- involving "image/t38" (e.g., T.38oUDPTL, T.38oTCP):

  L: a:G729, fxr/fx:gw[image/t38]

- involving VBD (e.g., PCMU and V.152):

  L: a:G729;PCMU, gpmd/gpmd:"PCMU vbd=yes", fxr/fx:gw[audio/PCMU]

- involving VBD with redundancy (e.g., PCMU, V.152, and RFC 2198):

  L: a:G729;RED;PCMU, fmtp:"RED PCMU/PCMU",
     gpmd/gpmd:"PCMU vbd=yes", fxr/fx:gw[audio/RED|audio/PCMU]

Only "special fax handling" involving one of the specified MIME types is authorized. Support for "special fax handling" involving one of the specified MIME types MUST be negotiated, or this "instance" of the gateway procedure is not initiated. Consider the following example in which the Call Agent authorizes the use of a gateway controlled fax handling procedure:

- involving "audio/t38" (e.g., T.38oRTP):

  L: a:G729;t38, fxr/fx:gw[audio/t38]

In this example, the call will fail if the gateway fails to negotiate "audio/t38".

The "fx" LocalConnectionOption MAY now involve multiple instances of the "gw" parameter, each with a different list of MIME types. In order to authorize "no special fax handling", the Call Agent MUST include the "gw" parameter without a MIME type, or the "off"

parameter. The instance of the "gw" parameter without a MIME type should appear as the last instance of the "gw" parameter. In the following example,

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

the Call Agent authorizes the use of, and expresses a preference for,

1. Gateway controlled image/t38 (e.g., T.38oUDPTL)

2. Any other gateway procedure with "special fax handling"

3. No special fax handling (this is a function of the "fxr/fx:gw" parameter as defined in Section 2.1 of the MGCP Fax (FXR) package [RFC5347])

If present, the "off" parameter should appear as the last parameter. In the following example,

```
L: a:G729;PCMU;t38, fxr/fx:gw[audio/t38];off
```

the Call Agent authorizes the use of, and expresses a preference for,

1. Gateway controlled audio/t38 (e.g., T.38oRTP)

2. No special fax handling

We can express relative preferences for different gateway controlled fax handling procedures, not only with respect to one another, but with respect to T.38 procedures. Consider the following preferential list of fax handling procedures:

1. Gateway controlled audio/t38 (e.g., T.38oRTP)

2. Gateway controlled image/t38 (e.g., T.38oUDPTL)

3. Call Agent controlled image/t38

4. Gateway controlled VBD with redundancy (e.g., PCMU, V.152, and RFC 2198)

5. Gateway controlled VBD without redundancy (e.g., PCMU and V.152)

6. Any other gateway procedure with "special fax handling"

7. No special fax handling (this is a function of the "fxr/fx:gw" parameter as defined in Section 2.1 of the MGCP Fax (FXR) package [RFC5347])

This would be expressed as

```
  L: a:G729;PCMU;t38;RED;PCMU,
     gpmd/gpmd:"PCMU:2 vbd=yes",
     fmtp:"RED PCMU:2/PCMU:2",
     fxr/fx:gw[audio/t38|image/t38];t38;gw[audio/RED|audio/PCMU:2];gw
```

Note that the bracketed form of the "gw" parameter is NOT defined as part of the VBD package. The bracketed form of the "gw" parameter is defined as an extension to the FXR package. Gateways that implement the bracketed form of the "gw" parameter MUST return this form of the parameter when capabilities are audited as illustrated by the following example:

```
     A: fxr/fx:t38;t38-loose;gw[audio/t38|image/t38];gw;off
```

Support for the bracketed "gw" parameter MAY be spread across multiple capability lines:

```
     A: a:RED;PCMU, p:10-40, e:on, s:off,
        m:sendonly;recvonly;sendrecv;inactive,
        gpmd/gpmd:"PCMU vbd=yes",
          fmtp:"RED PCMU/PCMU",
          fxr/fx:gw[audio/RED|audio/PCMU]
     A: a:t38, fxr/fx:gw[audio/t38]
     A: a:image/t38, fxr/fx:t38;t38-loose;gw[image/t38]
```

A Call Agent SHOULD only attempt to leverage the bracketed form of the "gw" parameter in conjunction with an endpoint that indicates support for the bracketed syntax as part of its capabilities.

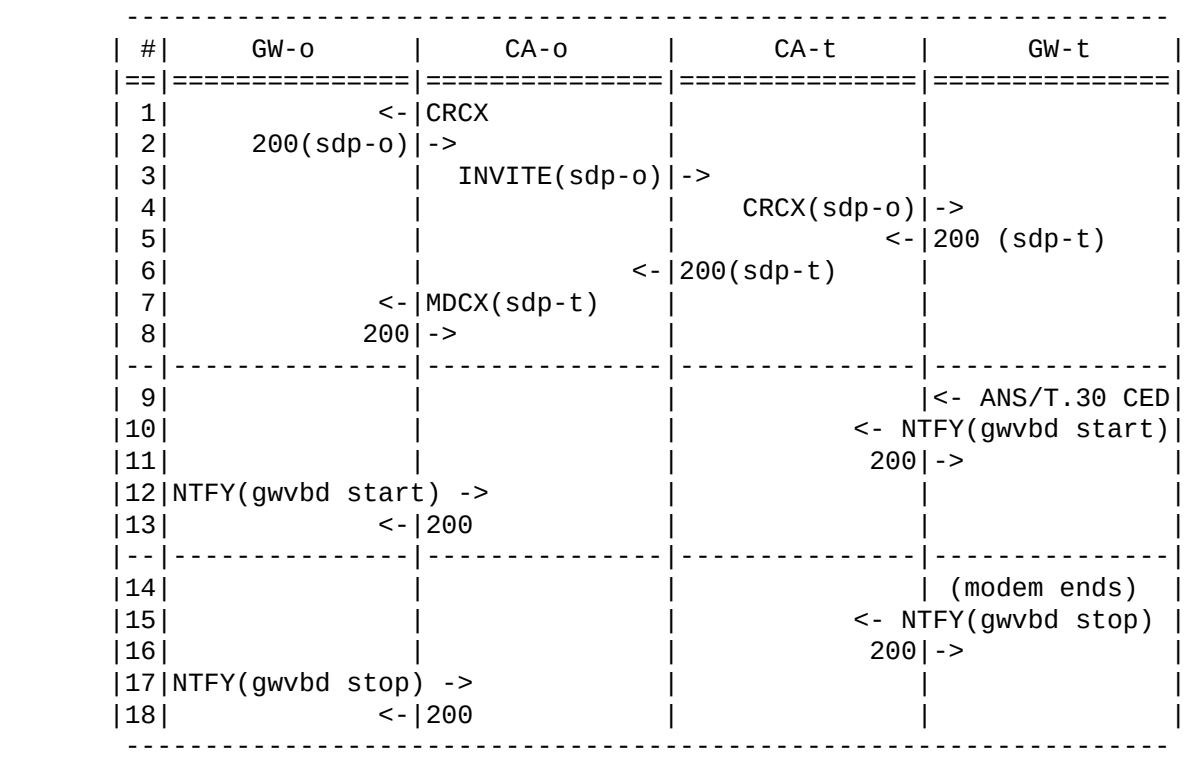
Call Agents and gateways that do not support this form of the "gw" parameter MUST ignore the bracketed MIME type information consistent with the MGCP grammar [RFC3435].

9. Call Flow Examples

In this section, we provide two call flow examples. The first one illustrates a modem call under gateway control using V.152. The second one illustrates a fax call under gateway control using V.152 and Call Agent controlled T.38.

9.1. Modem Call with Gateway Controlled VBD

In this example, both sides support gateway controlled VBD using V.152 with redundancy. We assume that the originating and terminating Call Agents communicate via the Session Initiation Protocol (SIP) [RFC3261]:



Step 1:

The Call Agent issues a CreateConnection command to the gateway, instructing it to use G.729 media encoding and to notify it of the "gwvbd" and "nopvbd" events. The Call Agent authorizes the negotiation of G.711u as a VBD codec with a redundancy level of one:

```
CRCX 1000 ds/ds1-1/1@gw-o.whatever.net MGCP 1.0
C: 1
L: a:G729;RED;PCMU, gpmd/gpmd:"PCMU vbd=yes", fmtp:"RED PCMU/PCMU"
M: recvonly
R: vbd/gwvbd, vbd/nopvbd
X: 1
Q: process, loop
```

Step 2:

The gateway acknowledges the command and includes SDP with codec information as well as V.152 and redundancy 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 18 96 97
a=rtpmap:96 RED/8000
a=fmtp:96 97/97
a=rtpmap:97 PCMU/8000
a=gpmd:97 vbd=yes
```

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 G.729 media encoding and to notify it of the "gwvbd" and "nopvbd" events. Again, the Call Agent authorizes the negotiation of G.711u as a VBD codec with a redundancy level of one:

```
CRCX 2000 ds/ds1-1/2@gw-t.whatever.net MGCP 1.0
C: 2
L: a:G729;RED;PCMU, gpmd/gpmd:"PCMU vbd=yes", fmtp:"RED PCMU/PCMU"
M: sendrecv
R: vbd/gwvbd, vbd/nopvbd
X: 20
Q: process, loop
```

```
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 18 96 97
a=rtpmap:96 RED/8000
a=fmtp:96 97/97
a=rtpmap:97 PCMU/8000
a=gpmd:97 vbd=yes
```

Step 5:

The terminating gateway supports V.152 and redundancy, and the RemoteConnectionDescriptor included indicates that the other side supports V.152 and redundancy. The terminating gateway sends back a success response with its SDP, which also includes V.152 and redundancy 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 18 96 97
a=rtpmap:96 RED/8000
a=fmtp:96 97/97
a=rtpmap:97 PCMU/8000
a=gpmd:97 vbd=yes
```

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.whatever.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 18 96 97
a=rtpmap:96 RED/8000
a=fmtp:96 97/97
a=rtpmap:97 PCMU/8000
a=gpmd:97 vbd=yes
```

Since the RemoteConnectionDescriptor indicates that the other side supports V.152 and redundancy, the gateway will in fact be able to use the gateway controlled VBD procedure with redundancy. Had there not been any support for V.152 in the RemoteConnectionDescriptor, then this command would still have succeeded; however, there would be no negotiated procedure for VBD handling.

Step 8:

The gateway acknowledges the command. At this point, a call is established using G.729 encoding, and if a VBD call is detected, the gateway controlled VBD procedure will be initiated.

Steps 9-10:

A modem call now occurs. The terminating gateway detects a T.30 CED tone (a.k.a. V.25 ANS) in the GSTN-to-IP direction and begins transmitting RTP packets with the negotiated redundant VBD payload type (96).

The "gwvbd(start)" event occurs, and a Notify command is sent to the Call Agent:

```
NTFY 2500 ds/ds1-1/2@gw-t.whatever.net MGCP 1.0
O: vbd/gwvbd(start, rc=ANS, codec=audio/RED, coord=v152ptsw)
X: 20
```

Step 11:

The Call Agent acknowledges the Notify command:

```
200 2500 OK
```

Step 12:

Upon receiving an RTP packet with the redundant VBD payload type (96), the originating gateway begins transmitting RTP packets with the redundant VBD payload type.

The "gwvbd(start)" event occurs, and a Notify command is sent to the Call Agent:

```
NTFY 1500 ds/ds1-1/1@gw-o.whatever.net MGCP 1.0
O: vbd/gwvbd(start, rc=PTSW, codec=audio/RED)
X: 1
```

Step 13:

The Call Agent acknowledges the Notify command:

```
200 1500 OK
```

Steps 14-15:

The modem call ends. The terminating gateway detects bidirectional silence and begins transmitting RTP packets with the negotiated audio payload type (18).

The "gwvbd(stop)" event occurs, and a Notify command is sent to the Call Agent:

```
NTFY 2501 ds/ds1-1/2@gw-t.whatever.net MGCP 1.0
O: vbd/gwvbd(stop, rc=SIL, codec=audio/G729)
X: 20
```

Step 16:

The Call Agent acknowledges the Notify command:

```
200 2501 OK
```

Step 17:

Upon receiving an RTP packet with the audio payload type (18), the originating gateway begins transmitting RTP packets with the audio payload type.

The "gwvbd(stop)" event occurs, and a Notify command is sent to the Call Agent:

```
NTFY 1501 ds/ds1-1/1@gw-o.whatever.net MGCP 1.0
O: vbd/gwvbd(stop, rc=PTSW, codec=audio/G729)
X: 1
```

Step 18:

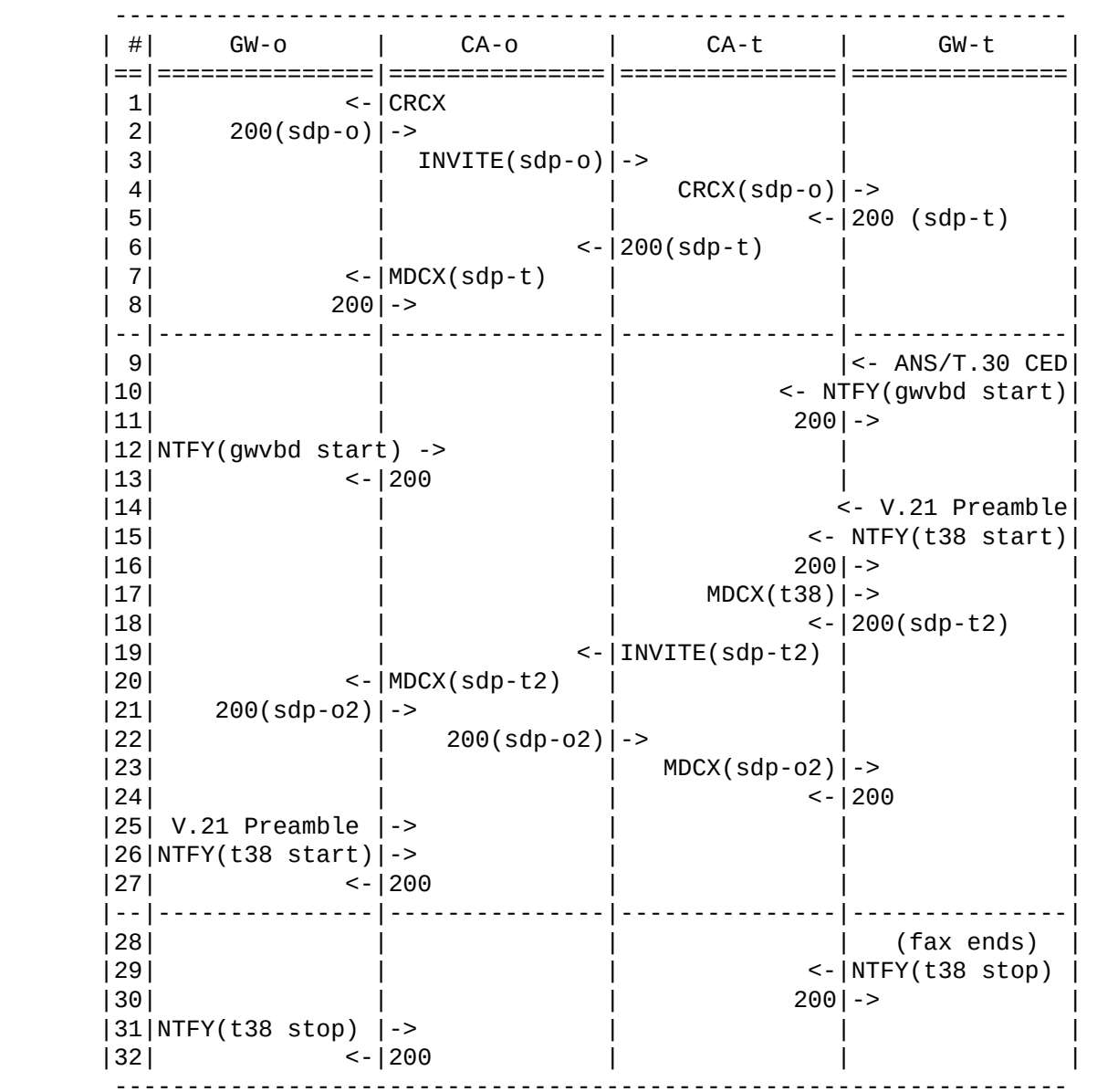
The Call Agent acknowledges the Notify command:

```
200 1501 OK
```

The modem call is now over.

9.2. Fax Call with Gateway Controlled VBD and Call Agent Controlled T.38

In this example, both sides support gateway controlled VBD using V.152 with redundancy and Call Agent controlled T.38. We assume that the originating and terminating Call Agent communicate via the Session Initiation Protocol (SIP) [RFC3261]:



Step 1:

The Call Agent issues a CreateConnection command to the gateway, instructing it to use G.729 media encoding and to use either the strict T.38 procedure or the gateway procedure. Consequently, the Call Agent requests notification of the "t38", "gwfax", "gwvbd", and "nopvbd" events. The Call Agent authorizes the negotiation of G.711u as a VBD codec with a redundancy level of one:

```
CRCX 1000 ds/ds1-1/1@gw-o.whatever.net MGCP 1.0
C: 1
L: a:G729;RED;PCMU, gpmd/gpmd:"PCMU vbd=yes", fmtp:"RED PCMU/PCMU",
   fxr/fx:t38;gw
M: recvonly
R: fxr/t38, fxr/gwfax, vbd/gwvbd, vbd/nopvbd
X: 1
Q: process, loop
```

Step 2:

The gateway acknowledges the command and includes SDP with codec information as well as capability, V.152, and redundancy 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
a=pmft: T38
m=audio 3456 RTP/AVP 18 96 97
a=rtpmap:96 RED/8000
a=fmtp:96 97/97
a=rtpmap:97 PCMU/8000
a=gpmd:97 vbd=yes
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 18 96 97
a=cdsc: 4 image udptl t38
```

Note that V.152 requires the use of the session-level "a=pmft" SDP attribute in order to express a preference for T.38 over V.152 for fax handling.

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 G.729 media encoding and to use either the strict T.38 procedure or the gateway procedure. Consequently, the Call Agent requests

notification of the "t38", "gwfax", "gwvbd", and "nopvbd" events. Again, the Call Agent authorizes the negotiation of G.711u as a VBD codec with a redundancy level of one:

```
CRCX 2000 ds/ds1-1/2@gw-t.whatever.net MGCP 1.0
C: 2
L: a:G729;RED;PCMU, gpmd/gpmd:"PCMU vbd=yes", fmtp:"RED PCMU/PCMU",
   fxr/fx:t38;gw
M: sendrecv
R: fxr/t38, fxr/gwfax, vbd/gwvbd, vbd/nopvbd
X: 20
Q: process, loop

v=0
o=- 25678 753849 IN IP4 192.0.2.1
s=-
c=IN IP4 192.0.2.1
t=0 0
a=pmft: T38
m=audio 3456 RTP/AVP 18 96 97
a=rtpmap:96 RED/8000
a=fmtp:96 97/97
a=rtpmap:97 PCMU/8000
a=gpmd:97 vbd=yes
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 18 96 97
a=cdsc: 4 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 supports V.152 and redundancy, and the RemoteConnectionDescriptor included indicates that the other side supports V.152 and redundancy, so gateway controlled VBD using V.152 and redundancy can be used for modem and text transmissions. The terminating gateway sends back a success response with its SDP, which also includes capability, V.152, and redundancy 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
a=pmft: T38
m=audio 1296 RTP/AVP 18 96 97
a=rtpmap:96 RED/8000
a=fmtp:96 97/97
a=rtpmap:97 PCMU/8000
a=gpmd:97 vbd=yes
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 18 96 97
a=cdsc: 4 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.whatever.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
a=pmft: T38
m=audio 1296 RTP/AVP 18 96 97
a=rtpmap:96 RED/8000
a=fmtp:96 97/97
a=rtpmap:97 PCMU/8000
a=gpmd:97 vbd=yes
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 18 96 97
a=cdsc: 4 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 that the other side supports T.38, the gateway will in fact be able to use the strict Call Agent controlled T.38 procedure. Since the

RemoteConnectionDescriptor indicates that the other side supports V.152 and redundancy, the gateway will in fact be able to use the V.152 VBD procedure with redundancy.

Step 8:

The gateway acknowledges the command. At this point, a call is established using G.729 encoding, and if a fax call is detected, the Call Agent controlled T.38 procedure will be initiated. If a modem or text call is detected, the V.152 VBD procedure will be initiated.

Steps 9-10:

The terminating gateway detects the T.30 CED tone (a.k.a. V.25 ANS). 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 14, where the V.21 fax preamble is detected. The terminating gateway begins transmitting RTP packets with the negotiated redundant VBD payload type (96).

The "gwvbd(start)" event occurs, and a Notify command is sent to the Call Agent:

```
NTFY 2500 ds/ds1-1/2@gw-t.whatever.net MGCP 1.0
O: vbd/gwvbd(start, rc=ANS, codec=audio/RED, coord=v152ptsw)
X: 20
```

Step 11:

The Call Agent acknowledges the Notify command:

```
200 2500 OK
```

Step 12:

Upon receiving an RTP packet with the redundant VBD payload type (96), the originating gateway begins transmitting RTP packets with the redundant VBD payload type.

The "gwvbd(start)" event occurs, and a Notify command is sent to the Call Agent:

```
NTFY 1500 ds/ds1-1/1@gw-o.whatever.net MGCP 1.0
O: vbd/gwvbd(start, rc=PTSW, codec=audio/RED)
X: 1
```

Step 13:

The Call Agent acknowledges the Notify command:

```
200 1500 OK
```

Steps 14-15:

The terminating gateway detects the V.21 fax preamble.

The terminating gateway is using the Call Agent controlled T.38 strict procedure for fax calls, so the "t38(start)" event occurs, and a Notify command is sent to the Call Agent:

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

Step 16:

The Call Agent acknowledges the Notify command:

```
200 2500 OK
```

Step 17:

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

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

Note that the Call Agent is no longer requesting notification of the "gwvbd" event.

Step 18:

The terminating gateway sends back a success response with its SDP, which also includes the "image/t38" media description:

```
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=sqn: 0
a=cdsc: 1 audio RTP/AVP 18 96 97
a=cpar: a=rtpmap:96 RED/8000
a=cpar: a=fmtp:96 97/97
a=cpar: a=rtpmap:97 PCMU/8000
a=cpar: a=gpmd:97 vbd=yes
a=cdsc: 4 image udptl t38
```

The gwvbd procedure ends due to the media type change. The "gwvbd(stop)" event notification would normally be sent at this point; however, the Call Agent is no longer requesting notification of the "gwvbd" event. The Call Agent would have inferred from the "t38(start)" event that the gwvbd procedure ended.

Step 19:

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

Step 20:

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

```
MDCX 1003 ds/ds1-1/1@gw-o.whatever.net MGCP 1.0
C: 1
I: 1
R: fxr/t38
X: 2

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=sqn: 0
a=cdsc: 1 audio RTP/AVP 18 96 97
a=cpar: a=rtpmap:96 RED/8000
a=cpar: a=fmtp:96 97/97
a=cpar: a=rtpmap:97 PCMU/8000
a=cpar: a=gpmd:97 vbd=yes
a=cdsc: 4 image udptl t38
```

Step 21:

The originating gateway changes to T.38 and sends back a success response with the 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 udptl t38
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 18 96 97
a=cpar: a=rtpmap:96 RED/8000
a=cpar: a=fmtp:96 97/97
a=cpar: a=rtpmap:97 PCMU/8000
a=cpar: a=gpmd:97 vbd=yes
a=cdsc: 4 image udptl t38
```

Again, the gwvbd procedure ends due to the media type change. The "gwvbd(stop)" event notification would normally be sent at this point; however, the Call Agent is no longer requesting notification of the "gwvbd" event.

Step 22:

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 23:

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

```
MDCX 2002 ds/ds1-1/2@gw-t.whatever.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 udptl t38
a=sqn: 0
a=cdsc: 1 audio RTP/AVP 18 96 97
a=cpar: a=rtpmap:96 RED/8000
a=cpar: a=fmtp:96 97/97
a=cpar: a=rtpmap:97 PCMU/8000
a=cpar: a=gpmd:97 vbd=yes
a=cdsc: 4 image udptl t38
```

Steps 24-32:

These steps correspond to the Call Agent controlled T.38 strict procedure as defined in the MGCP Fax (FXR) package [RFC5347].

10. Security Considerations

This document defines two new packages, both of which have security considerations in two areas:

1. MGCP signaling message security

2. Media stream security

From an MGCP signaling security point of view, the MGCP VBD and GPMD packages define extensions to the basic MGCP signaling specification in accordance with the procedures specified in MGCP [RFC3435], and hence the MGCP signaling security considerations and recommendations provided in Section 5 of [RFC3435] (namely the use of IPsec) apply here as well. Lack of MGCP signaling integrity protection can in general be detrimental to any use of MGCP, and the two packages defined here do not change that. From a confidentiality point of view, the VBD package is not believed to convey any vulnerable or privacy-sensitive information. The GPMD package is slightly different inasmuch as it does not define any specific parameters that

are believed to require confidentiality; however, it is a generic parameter that can carry any codec parameter information, and hence it is possible that confidential information is conveyed through this parameter. If confidentiality of any such potential information is a concern, confidentiality protection of the MGCP signaling MUST be provided as well. It should be noted that Section 8 of [RFC5406] provides considerations for specifying the use of IPsec that are above and beyond those provided in [RFC3435]; however, given that the use of IPsec for MGCP applies to all of MGCP, and not just the MGCP VBD and GPMD packages, we do not specify such additional detail here.

From a media stream security point of view, the MGCP VBD and GPMD packages again define extensions that rely on the general use of media streams defined in MGCP [RFC3435], and hence the MGCP media stream security considerations and recommendations provided in Section 5.1 of [RFC3435] apply here as well. Lack of media stream security can in general be detrimental to any media stream established via MGCP, and the two packages defined here do not change that. Confidentiality concerns apply as for any other media stream. Integrity concerns are further compounded by the GPMD package's use of payload type switching, state signaling events, and media stream in-band triggers to drive overall Voiceband Data operation: Integrity protection with replay protection MUST be used to counter these threats.

Ideally, there would be a single mandatory-to-implement media stream security mechanism to provide this integrity protection, and in theory there is, since MGCP [RFC3435] defines a media stream security mechanism. However, the standard MGCP media stream security mechanism defined in [RFC3435] relies on the encryption key ("k=") field defined in the original SDP specification [RFC2327], the use of which is no longer recommended in the current SDP specification [RFC4566]. In practice, this mechanism has also seen very limited implementation, and hence there is not much value in relying on it. Still, the integrity protection requirement remains, and there are several different ways this can be achieved:

Secure RTP: For RTP-based media streams, the use of Secure RTP [RFC3711] with an associated key management mechanism is generally preferred at the time of this writing; however, such a mechanism has currently not been defined for MGCP.

PacketCable Security: The PacketCable Network-Based Call Signaling Protocol [NCS] defines another media stream security mechanism that is generally supported by PacketCable-compliant implementations. Implementations targeted for those environments SHOULD implement this security mechanism.

Lower-Level Security: In the absence of a common media stream security mechanism supported by both endpoints, a lower-level security mechanism, e.g., IPsec, MUST be used. Note that since there is no inherent MGCP signaling support for such a lower-level security mechanism, it MUST be configured by other means.

11. IANA Considerations

The IANA has registered the following MGCP packages:

Package Title	Name	Version
Voiceband Data	VBD	0
General-Purpose Media Descriptor Parameter	GPMD	0

12. Acknowledgements

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