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RTP Payload Format for MELPe Codec
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Abstract

This document describes the RTP payload format for the Mixed Excitation Linear Prediction Enhanced (MELPe) speech coder. MELPe's three different speech encoding rates and sample frames sizes are supported. Comfort noise procedures and packet loss concealment are detailed.

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1 Introduction

This document describes how compressed MELPe speech as produced by the MELPe codec may be formatted for use as an RTP payload. Details are provided to packetize the three different codec bit-rate data frames (2400, 1200, and 600) into RTP packets. The sender may send one or more codec data frames per packet, depending on the application scenario or based on the transport network condition, bandwidth restriction, delay requirements and packet-loss tolerance.

1.1 Conventions, Definitions and Acronyms

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]. Best current practices for writing RTP payload format [RFC2736] were followed.

2 Background

The MELP speech coder was developed by the US military as an upgrade from LPC-based CELP standard vocoder for low bit-rate communications [MELP]. MELP was further enhanced and subsequently adopted by NATO as MELPe for use by its members and Partnership for Peace countries for military and other governmental communications [MELPE]. The MELP speech coder algorithm developed by Atlanta Signal Processing (ASPI), Texas Instruments (TI), SignalCom (now Microsoft) and Thales Communications with noise preprocessor contributions from AT&T under contract with NSA/DOD as international NATO Standard STANAG 4591.

Commercial/civilian applications have arisen because of the low bit-rate property of MELPe with its (relatively) high intelligibility. As such MELPe is being used in a variety of wired and radio communications systems. VoIP/SIP systems need to transport MELPe without decoding and re-encoding in order to preserve its intelligibility. Hence it is desirable and necessary to define the proper payload formatting and use conventions of MELPe in RTP payloads.

The MELPe codec [MELPE] supports three different vocoder bit rates; 2400, 1200, and 600 bps. The basic 2400 bps bit-rate vocoder uses a 22.5 ms frame of speech consisting of 180 8000 Hz, 16-bit speech samples. The 1200 and 600 bps bit-rate vocoders uses respectively three and four 22.5 ms frames of speech each. These reduced bit-rate vocoders internally use multiple 2400 bps parameter sets with further

processing to strategically remove redundancy. The payload sizes for each of the bitrates are 54, 81, and 54 bits respectively for the 2400, 1200, and 600 bps frames. Dynamic bit-rate switching is permitted but only if supported by both endpoints.

The MELPe algorithm distinguishes between voiced and un-voiced speech and encodes each differently. Unvoiced speech can be coded with fewer information bits for the same quality. Forward error correction (FEC) is applied to the 2400 bps codec unvoiced speech for better protection of the subtle differences in signal reconstruction. The lower bit-rate coders do not allocate any bits for FEC and rely on strong error protection and correction in the communications channel.

Comfort noise handling for MELPe is recommended to follow SCIP-210 Appendix B [SCIP210]. After VAD no longer indicates the presence of speech/voice, a grace period of a minimum of two comfort noise vocoder fames are to be transmitted. The contents of the comfort noise frames is described in the next section.

Packet loss concealment (PLC) exploits the FEC (and more precisely, any combination of two set bits in the pitch/voicing parameter) of the 2400 bps speech coder. The pitch/voicing parameter has a sparse set of permitted values. A value of zero indicates a non-voiced frame. At least three bits are set for all valid pitch parameters. The PLC erasure indication utilizes any of the two bit set errored/erasure encodings of a non-voiced frame as will be described infra.

3 Payload Format

The MELPe codec uses 22.5, 67.5 or 90 ms frames with a sampling rate clock of 8 kHz, so the RTP timestamp MUST be in units of 1/8000 of a second.

The RTP payload for MELPe has the format shown in the figure below. No additional header specific to this payload format is required.

This format is intended for the situations where the sender and the receiver send one or more codec data frames per packet. The RTP packet looks as follows:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          RTP Header                           |
+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
|                                                               |
+                   one or more frames of MELPe                 |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1 - Packet format diagram

The RTP header of the packetized encoded MELPe speech has the expected values as described in [RFC3550]. The usage of M bit SHOULD be as specified in the applicable RTP profile, for example, RFC 3551 [RFC3551], where [RFC3551] specifies that if the sender does not suppress silence (i.e., sends a frame on every frame interval), the M bit will always be zero. When more then one codec data frame is present in a single RTP packet, the timestamp is, as always, that of the oldest data frame represented in the RTP packet.

The assignment of an RTP payload type for this new packet format is outside the scope of this document, and will not be specified here. It is expected that the RTP profile for a particular class of applications will assign a payload type for this encoding, or if that is not done, then a payload type in the dynamic range shall be chosen by the sender.

3.1 MELPe Bitstream Definition

The total number of bits used to describe one frame of 2400 bps speech is 54, which fits in 7 octets (with two unused bits). For the 1200 bps speech the total number of bits used is 81, which fits in 11 octets (with seven unused bits). For the 600 bps speech the total number of bits used is 54, which fits in 7 octets (with two unused bits). Unused bits are coded as described in 3.3 in support of dynamic bit-rate switching.

In the MELPe bitstream definition, the most significant bits are considered priority bits. The intention was that these bits receive greater protection in the underlying communications channel. For IP networks, such additional protection is irrelevant. However, for convenience of interoperable gateway devices, the bitstreams will be presented identically in IP networks.

3.1.1 2400 bps Bitstream Structure

According to Table 3 of [MELPE], the 2400 bit/s MELPe bit transmission order (bit priority is not shown for clarity) is the following:

Bit	Voiced	Unvoiced
B_01	g20	g20
B_02	BP0	FEC10
B_03	P0	P0
B_04	LSF20	LSF20
B_05	LSF30	LSF30
B_06	g23	g23
B_07	g24	g24
B_08	LSF35	LSF35
B_09	g21	g21
B_10	g22	g22
B_11	P4	P4
B_12	LSF34	LSF34
B_13	P5	P5
B_14	P1	P1
B_15	P2	P2
B_16	LSF40	LSF40
B_17	P6	P6
B_18	LSF10	LSF10
B_19	LSF16	LSF16
B_20	LSF45	LSF45
B_21	P3	P3
B_22	LSF15	LSF15
B_23	LSF14	LSF14
B_24	LSF25	LSF25
B_25	BP3	FEC13
B_26	LSF13	LSF13
B_27	LSF12	LSF12
B_28	LSF24	LSF24
B_29	LSF44	LSF44
B_30	FM0	FEC40
B_31	LSF11	LSF11
B_32	LSF23	LSF23
B_33	FM7	FEC22
B_34	FM6	FEC21

B_35	FM5	FEC20
B_36	g11	g11
B_37	g10	g10
B_38	BP2	FEC12
B_39	BP1	FEC11
B_40	LSF21	LSF21
B_41	LSF33	LSF33
B_42	LSF22	LSF22
B_43	LSF32	LSF32
B_44	LSF31	LSF31
B_45	LSF43	LSF43
B_46	LSF42	LSF42
B_47	AF	FEC42
B_48	LSF41	LSF41
B_49	FM4	FEC32
B_50	FM3	FEC31
B_51	FM2	FEC30
B_52	FM1	FEC41
B_53	g12	g12
B_54	SYNC	SYNC

NOTES:
g = Gain
BP = Bandpass Voicing
P = Pitch/Voicing
LSF = Line Spectral Frequencies
FEC = Forward Error Correction Parity Bits
FM = Fourier Magnitudes
AF = Aperiodic Flag

B_01 = least significant bit of data set

Table 3.1 - The bitstream definition for MELPe 2400 bps.

The 2400 bps MELPe RTP payload is constructed as per Figure 2. Note that bit B_01 is placed in the LSB of the first byte with all other bits in sequence. When filling octets, the least significant bits of the seventh octet are filled with bits B_49 to B_54 respectively.

```
      MSB                                                 LSB
       0      1      2      3      4      5      6      7
   +------+------+------+------+------+------+------+------+
   | B_08 | B_07 | B_06 | B_05 | B_04 | B_03 | B_02 | B_01 |
   +------+------+------+------+------+------+------+------+
   | B_16 | B_15 | B_14 | B_13 | B_12 | B_11 | B_10 | B_09 |
   +------+------+------+------+------+------+------+------+
   | B_24 | B_23 | B_22 | B_21 | B_20 | B_19 | B_18 | B_17 |
   +------+------+------+------+------+------+------+------+
   | B_32 | B_31 | B_30 | B_29 | B_28 | B_27 | B_26 | B_25 |
   +------+------+------+------+------+------+------+------+
   | B_40 | B_39 | B_38 | B_37 | B_36 | B_35 | B_34 | B_33 |
   +------+------+------+------+------+------+------+------+
   | B_48 | B_47 | B_46 | B_45 | B_44 | B_43 | B_42 | B_41 |
   +------+------+------+------+------+------+------+------+
   | RSVA | RSVB | B_54 | B_53 | B_52 | B_51 | B_50 | B_49 |
   +------+------+------+------+------+------+------+------+
```

Figure 2 - Packed MELPe 2400 bps payload octets.

3.1.2 1200 bps Bitstream Structure

According to Tables D9a and D9b of [MELPE], the 1200 bit/s MELPe bit transmission order is the following:

Bit	Modes 1-4 (Voiced)	Mode 5 (Unvoiced)
B_01	Syn	Syn
B_02	Pitch&UV0	Pitch&UV0
B_03	Pitch&UV1	Pitch&UV1
B_04	Pitch&UV2	Pitch&UV2
B_05	Pitch&UV3	Pitch&UV3
B_06	Pitch&UV4	Pitch&UV4
B_07	Pitch&UV5	Pitch&UV5
B_08	Pitch&UV6	Pitch&UV6
B_09	Pitch&UV7	Pitch&UV7
B_10	Pitch&UV8	Pitch&UV8
B_11	Pitch&UV9	Pitch&UV9
B_12	Pitch&UV10	Pitch&UV10
B_13	Pitch&UV11	Pitch&UV11
B_14	LSP0	LSP0
B_15	LSP1	LSP1
B_16	LSP2	LSP2

```
+--------+-------------+-------------+
|  B_17  |    LSP3     |    LSP3     |
|  B_18  |    LSP4     |    LSP4     |
|  B_19  |    LSP5     |    LSP5     |
|  B_20  |    LSP6     |    LSP6     |
|  B_21  |    LSP7     |    LSP7     |
|  B_22  |    LSP8     |    LSP8     |
|  B_23  |    LSP9     |    LSP9     |
|  B_24  |    LSP10    |    LSP10    |
+--------+-------------+-------------+
|  B_25  |    LSP11    |    LSP11    |
|  B_26  |    LSP12    |    LSP12    |
|  B_27  |    LSP13    |    LSP13    |
|  B_28  |    LSP14    |    LSP14    |
|  B_29  |    LSP15    |    LSP15    |
|  B_30  |    LSP16    |    LSP16    |
|  B_31  |    LSP17    |    LSP17    |
|  B_32  |    LSP18    |    LSP18    |
+--------+-------------+-------------+
|  B_33  |    LSP19    |    LSP19    |
|  B_34  |    LSP20    |    LSP20    |
|  B_35  |    LSP21    |    LSP21    |
|  B_36  |    LSP22    |    LSP22    |
|  B_37  |    LSP23    |    LSP23    |
|  B_38  |    LSP24    |    LSP24    |
|  B_39  |    LSP25    |    LSP25    |
|  B_40  |    LSP26    |    LSP26    |
+--------+-------------+-------------+
|  B_41  |    LSP27    |    GAIN0    |
|  B_42  |    LSP28    |    GAIN1    |
|  B_43  |    LSP29    |    GAIN2    |
|  B_44  |    LSP30    |    GAIN3    |
|  B_45  |    LSP31    |    GAIN4    |
|  B_46  |    LSP32    |    GAIN5    |
|  B_47  |    LSP33    |    GAIN6    |
|  B_48  |    LSP34    |    GAIN7    |
+--------+-------------+-------------+
|  B_49  |    LSP35    |    GAIN8    |
|  B_50  |    LSP36    |    GAIN9    |
|  B_51  |    LSP37    |             |
|  B_52  |    LSP38    |             |
|  B_53  |    LSP39    |             |
|  B_54  |    LSP40    |             |
|  B_55  |    LSP41    |             |
|  B_56  |    LSP42    |             |
+--------+-------------+-------------+
|  B_57  |    GAIN0    |             |
|  B_58  |    GAIN1    |             |
```

```
        |  B_59  |    GAIN2    |             |
        |  B_60  |    GAIN3    |             |
        |  B_61  |    GAIN4    |             |
        |  B_62  |    GAIN5    |             |
        |  B_63  |    GAIN6    |             |
        |  B_64  |    GAIN7    |             |
        +--------+-------------+-------------+
        |  B_65  |    GAIN8    |             |
        |  B_66  |    GAIN9    |             |
        |  B_67  |     BP0     |             |
        |  B_68  |     BP1     |             |
        |  B_69  |     BP2     |             |
        |  B_70  |     BP3     |             |
        |  B_71  |     BP4     |             |
        |  B_72  |     BP5     |             |
        +--------+-------------+-------------+
        |  B_73  |   JITTER    |             |
        |  B_74  |     FS0     |             |
        |  B_75  |     FS1     |             |
        |  B_76  |     FS2     |             |
        |  B_77  |     FS3     |             |
        |  B_78  |     FS4     |             |
        |  B_79  |     FS5     |             |
        |  B_80  |     FS6     |             |
        +--------+-------------+-------------+
        |  B_81  |     FS7     |             |
        +--------+-------------+-------------+

        NOTES:
        BP = Band pass voicing
        FS = Fourier magnitudes
```

Table 3.2 - The bitstream definition for MELPe 1200 bps.

The 1200 bps MELPe RTP payload is constructed as per Figure 3. Note that bit B_01 is placed in the LSB of the first byte with all other bits in sequence. When filling octets, the least significant bit of the eleventh octet is filled with bit B_81.

MSB 0	1	2	3	4	5	6	LSB 7
B_08	B_07	B_06	B_05	B_04	B_03	B_02	B_01
B_16	B_15	B_14	B_13	B_12	B_11	B_10	B_09
B_24	B_23	B_22	B_21	B_20	B_19	B_18	B_17
B_32	B_31	B_30	B_29	B_28	B_27	B_26	B_25
B_40	B_39	B_38	B_37	B_36	B_35	B_34	B_33
B_48	B_47	B_46	B_45	B_44	B_43	B_42	B_41
B_56	B_55	B_54	B_53	B_52	B_51	B_50	B_49
B_64	B_63	B_62	B_61	B_60	B_59	B_58	B_57
B_72	B_71	B_70	B_69	B_68	B_67	B_66	B_65
B_80	B_79	B_78	B_77	B_76	B_75	B_74	B_73
RSVA	RSVB	RSVC	RSV0	RSV0	RSV0	RSV0	B_81

Figure 3 - Packed MELPe 1200 bps payload octets.

3.1.3 600 bps Bitstream Structure

According to Tables M-11 to M-16 of [MELPE], the 600 bit/s MELPe bit transmission order (bit priority is not shown for clarity) is the following:

Bit	Mode 1 (Voiced)	Mode 2 (voiced)	Mode 3 (voiced)
B_01	Voicing (4)	Voicing (4)	Voicing (4)
B_02	Voicing (3)	Voicing (3)	Voicing (3)
B_03	Voicing (2)	Voicing (2)	Voicing (2)
B_04	Voicing (1)	Voicing (1)	Voicing (1)
B_05	Voicing (0)	Voicing (0)	Voicing (0)
B_06	LSF1,4 (3)	Pitch (5)	Pitch (7)
B_07	LSF1,4 (2)	Pitch (4)	Pitch (6)
B_08	LSF1,4 (1)	Pitch (3)	Pitch (5)

B_09	LSF1,4 (0)	Pitch (2)	Pitch (4)
B_10	LSF1,3 (3)	Pitch (1)	Pitch (3)
B_11	LSF1,3 (2)	Pitch (0)	Pitch (2)
B_12	LSF1,3 (1)	LSF1,3 (3)	Pitch (1)
B_13	LSF1,3 (0)	LSF1,3 (2)	Pitch (0)
B_14	LSF1,2 (3)	LSF1,3 (1)	LSF1,3 (3)
B_15	LSF1,2 (2)	LSF1,3 (0)	LSF1,3 (2)
B_16	LSF1,2 (1)	LSF1,2 (3)	LSF1,3 (1)
B_17	LSF1,2 (0)	LSF1,2 (2)	LSF1,3 (0)
B_18	LSF1,1 (5)	LSF1,2 (1)	LSF1,2 (4)
B_19	LSF1,1 (4)	LSF1,2 (0)	LSF1,2 (3)
B_20	LSF1,1 (3)	LSF1,1 (5)	LSF1,2 (2)
B_21	LSF1,1 (2)	LSF1,1 (4)	LSF1,2 (1)
B_22	LSF1,1 (1)	LSF1,1 (3)	LSF1,2 (0)
B_23	LSF1,1 (0)	LSF1,1 (2)	LSF1,1 (5)
B_24	LSF2,4 (3)	LSF1,1 (1)	LSF1,1 (4)
B_25	LSF2,4 (2)	LSF1,1 (0)	LSF1,1 (3)
B_26	LSF2,4 (1)	LSF2,3 (3)	LSF1,1 (2)
B_27	LSF2,4 (0)	LSF2,3 (2)	LSF1,1 (1)
B_28	LSF2,3 (3)	LSF2,3 (1)	LSF1,1 (0)
B_29	LSF2,3 (2)	LSF2,3 (0)	LSF2,3 (3)
B_30	LSF2,3 (1)	LSF2,2 (4)	LSF2,3 (2)
B_31	LSF2,3 (0)	LSF2,2 (3)	LSF2,3 (1)
B_32	LSF2,2 (3)	LSF2,2 (2)	LSF2,3 (0)
B_33	LSF2,2 (2)	LSF2,2 (1)	LSF2,2 (4)
B_34	LSF2,2 (1)	LSF2,2 (0)	LSF2,2 (3)
B_35	LSF2,2 (0)	LSF2,1 (6)	LSF2,2 (2)
B_36	LSF2,1 (5)	LSF2,1 (5)	LSF2,2 (1)
B_37	LSF2,1 (4)	LSF2,1 (4)	LSF2,2 (0)
B_38	LSF2,1 (3)	LSF2,1 (3)	LSF2,1 (5)
B_39	LSF2,1 (2)	LSF2,1 (2)	LSF2,1 (4)
B_40	LSF2,1 (1)	LSF2,1 (1)	LSF2,1 (3)
B_41	LSF2,1 (0)	LSF2,1 (0)	LSF2,1 (2)
B_42	GAIN2 (5)	GAIN2 (5)	LSF2,1 (1)
B_43	GAIN2 (4)	GAIN2 (4)	LSF2,1 (0)
B_44	GAIN2 (3)	GAIN2 (3)	GAIN2 (4)
B_45	GAIN2 (2)	GAIN2 (2)	GAIN2 (3)
B_46	GAIN2 (1)	GAIN2 (1)	GAIN2 (2)
B_47	GAIN2 (0)	GAIN2 (0)	GAIN2 (1)
B_48	GAIN1 (6)	GAIN1 (6)	GAIN2 (0)
B_49	GAIN1 (5)	GAIN1 (5)	GAIN1 (5)
B_50	GAIN1 (4)	GAIN1 (4)	GAIN1 (4)

B_51	GAIN1 (3)	GAIN1 (3)	GAIN1 (3)
B_52	GAIN1 (2)	GAIN1 (2)	GAIN1 (2)
B_53	GAIN1 (1)	GAIN1 (1)	GAIN1 (1)
B_54	GAIN1 (0)	GAIN1 (0)	GAIN1 (0)

Table 3.3a - The bitstream definition for MELPe 600 bps (part 1 of 2).

Bit	Mode 4 (voiced)	Mode 5 (voiced)	Mode 6 (voiced)
B_01	Voicing (4)	Voicing (4)	Voicing (4)
B_02	Voicing (3)	Voicing (3)	Voicing (3)
B_03	Voicing (2)	Voicing (2)	Voicing (2)
B_04	Voicing (1)	Voicing (1)	Voicing (1)
B_05	Voicing (0)	Voicing (0)	Voicing (0)
B_06	Pitch (7)	Pitch (7)	Pitch (7)
B_07	Pitch (6)	Pitch (6)	Pitch (6)
B_08	Pitch (5)	Pitch (5)	Pitch (5)
B_09	Pitch (4)	Pitch (4)	Pitch (4)
B_10	Pitch (3)	Pitch (3)	Pitch (3)
B_11	Pitch (2)	Pitch (2)	Pitch (2)
B_12	Pitch (1)	Pitch (1)	Pitch (1)
B_13	Pitch (0)	Pitch (0)	Pitch (0)
B_14	LSF1,3 (3)	LSF1,3 (3)	LSF1,3 (3)
B_15	LSF1,3 (2)	LSF1,3 (2)	LSF1,3 (2)
B_16	LSF1,3 (1)	LSF1,3 (1)	LSF1,3 (1)
B_17	LSF1,3 (0)	LSF1,3 (0)	LSF1,3 (0)
B_18	LSF1,2 (3)	LSF1,2 (4)	LSF1,2 (4)
B_19	LSF1,2 (2)	LSF1,2 (3)	LSF1,2 (3)
B_20	LSF1,2 (1)	LSF1,2 (2)	LSF1,2 (2)
B_21	LSF1,2 (0)	LSF1,2 (1)	LSF1,2 (1)
B_22	LSF1,1 (5)	LSF1,2 (0)	LSF1,2 (0)
B_23	LSF1,1 (4)	LSF1,1 (5)	LSF1,1 (6)
B_24	LSF1,1 (3)	LSF1,1 (4)	LSF1,1 (5)
B_25	LSF1,1 (2)	LSF1,1 (3)	LSF1,1 (4)
B_26	LSF1,1 (1)	LSF1,1 (2)	LSF1,1 (3)
B_27	LSF1,1 (0)	LSF1,1 (1)	LSF1,1 (2)
B_28	LSF2,3 (3)	LSF1,1 (0)	LSF1,1 (1)
B_29	LSF2,3 (2)	LSF2,3 (3)	LSF1,1 (0)
B_30	LSF2,3 (1)	LSF2,3 (2)	LSF2,3 (3)
B_31	LSF2,3 (0)	LSF2,3 (1)	LSF2,3 (2)
B_32	LSF2,2 (4)	LSF2,3 (0)	LSF2,3 (1)

B_33	LSF2,2 (3)	LSF2,2 (4)	LSF2,3 (0)
B_34	LSF2,2 (2)	LSF2,2 (3)	LSF2,2 (4)
B_35	LSF2,2 (1)	LSF2,2 (2)	LSF2,2 (3)
B_36	LSF2,2 (0)	LSF2,2 (1)	LSF2,2 (2)
B_37	LSF2,1 (6)	LSF2,2 (0)	LSF2,2 (1)
B_38	LSF2,1 (5)	LSF2,1 (5)	LSF2,2 (0)
B_39	LSF2,1 (4)	LSF2,1 (4)	LSF2,1 (6)
B_40	LSF2,1 (3)	LSF2,1 (3)	LSF2,1 (5)
B_41	LSF2,1 (2)	LSF2,1 (2)	LSF2,1 (4)
B_42	LSF2,1 (1)	LSF2,1 (1)	LSF2,1 (3)
B_43	LSF2,1 (0)	LSF2,1 (0)	LSF2,1 (2)
B_44	GAIN2 (4)	GAIN2 (4)	LSF2,1 (1)
B_45	GAIN2 (3)	GAIN2 (3)	LSF2,1 (0)
B_46	GAIN2 (2)	GAIN2 (2)	GAIN1 (8)
B_47	GAIN2 (1)	GAIN2 (1)	GAIN1 (7)
B_48	GAIN2 (0)	GAIN2 (0)	GAIN1 (6)
B_49	GAIN1 (5)	GAIN1 (5)	GAIN1 (5)
B_50	GAIN1 (4)	GAIN1 (4)	GAIN1 (4)
B_51	GAIN1 (3)	GAIN1 (3)	GAIN1 (3)
B_52	GAIN1 (2)	GAIN1 (2)	GAIN1 (2)
B_53	GAIN1 (1)	GAIN1 (1)	GAIN1 (1)
B_54	GAIN1 (0)	GAIN1 (0)	GAIN1 (0)

Notes:
xxxx (0) = LSB
xxxx (nbits-1) = MSB
LSF1,p = MSVQ indice of the pth stage of the two first frames
LSF2,p = MSVQ indice of the pth stage of the two last frames
GAIN1 = VQ/MSVQ indice of the 1st stage
GAIN2 = MSVQ indice of the 2nd stage

Table 3.3b - The bitstream definition for MELPe 600 bps (part 2 of 2).

The 600 bps MELPe RTP payload is constructed as per Figure 4. Note that bit B_01 is placed in the LSB of the first byte with all other bits in sequence. When filling octets, the least significant bits of the seventh octet are filled with bits B_49 to B_54 respectively.

```
    MSB                                          LSB
     0      1      2      3      4      5      6      7
  +------+------+------+------+------+------+------+------+
  | B_08 | B_07 | B_06 | B_05 | B_04 | B_03 | B_02 | B_01 |
  +------+------+------+------+------+------+------+------+
  | B_16 | B_15 | B_14 | B_13 | B_12 | B_11 | B_10 | B_09 |
  +------+------+------+------+------+------+------+------+
  | B_24 | B_23 | B_22 | B_21 | B_20 | B_19 | B_18 | B_17 |
  +------+------+------+------+------+------+------+------+
  | B_32 | B_31 | B_30 | B_29 | B_28 | B_27 | B_26 | B_25 |
  +------+------+------+------+------+------+------+------+
  | B_40 | B_39 | B_38 | B_37 | B_36 | B_35 | B_34 | B_33 |
  +------+------+------+------+------+------+------+------+
  | B_48 | B_47 | B_46 | B_45 | B_44 | B_43 | B_42 | B_41 |
  +------+------+------+------+------+------+------+------+
  | RSVA | RSVB | B_54 | B_53 | B_52 | B_51 | B_50 | B_49 |
  +------+------+------+------+------+------+------+------+
```

Figure 4 - Packed MELPe 600 bps payload octets.

3.2 MELPe Comfort Noise Bitstream Definition

Table B.3-1 of [SCIP210] identifies the usage of MELPe 2400 bps parameters for conveying comfort noise.

MELPe Parameter	Value
msvq[0] (line spectral frequencies)	* See Note
msvq[1] (line spectral frequencies)	Set to 0
msvq[2] (line spectral frequencies)	Set to 0
msvq[3] (line spectral frequencies)	Set to 0
fsvq (Fourier magnitudes)	Set to 0
gain[0] (gain)	Set to 0
gain[1] (gain)	* See Note
pitch (pitch - overall voicing)	Set to 0
bp (bandpass voicing)	Set to 0
af (aperiodic flag/jitter index)	Set to 0
sync (sync bit)	Alternations

Note: The default value shall be the respective parameters from the vocoder frame. It is recommended that msvq[0] and gain[1] values be derived by averaging the respective parameter from some number of previous vocoder frames.

Table 3.4 - MELPe Comfort Noise Parameters

Since only msvq[0] (also known as LSF1x or the first LSP) and gain[1] (also known as g2x or the second gain) are required, the following bit order is used for comfort noise frames.

Bit	Comfort Noise
B_01	LSF10
B_02	LSF11
B_03	LSF12
B_04	LSF13
B_05	LSF14
B_06	LSF15
B_07	LSF16
B_08	g20
B_09	g21
B_10	g22
B_11	g23
B_12	g24
B_13	SYNC

NOTES:
g = Gain
LSF = Line Spectral Frequencies

Table 3.5 - The bitstream definition for MELPe Comfort Noise.

The Comfort Noise MELPe RTP payload is constructed as per Figure 5. Note that bit B_01 is placed in the LSB of the first byte with all other bits in sequence. When When filling octets, the least significant bits of the second octet are filled with bits B_09 to B_13 respectively.

```
   MSB                                              LSB
    0      1      2      3      4      5      6      7
+------+------+------+------+------+------+------+------+
| B_08 | B_07 | B_06 | B_05 | B_04 | B_03 | B_02 | B_01 |
+------+------+------+------+------+------+------+------+
| RSVA | RSVB | RSVC | B_13 | B_12 | B_11 | B_10 | B_09 |
+------+------+------+------+------+------+------+------+
```

Figure 5 - Packed MELPe Comfort Noise payload octets.

3.3 Multiple MELPe frames in a RTP packet

A MELPe RTP packet may consist of zero or more MELPe coder frames,

followed by zero or one MELPe Comfort Noise frames. The presence of a comfort noise frame can be deduced from the length of the RTP payload. The default packetization interval is one coder frame (22.5, 67.5 or 90 ms) according to the coder bit rate (2400, 1200 or 600 bps). For some applications, a longer packetization interval may be required to reduce the packet rate.

A MELPe RTP packet comprised of no coder frame and no comfort noise frame may be used periodically by an end point to indicate connectivity by an otherwise idle receiver.

All MELPe frames in a single RTP packet MUST be of the same coder bit rate. Dynamic switching between frame rates within an RTP stream may be permitted (if supported by both ends) provided that reserved bits, RSVA, RSVB, and RSVC are filled in as per Table 3.6. If bit-rate switching is not used, all reserved bits are encoded as 0 by the sender and ignored by the receiver. (RSV0 is always coded as 0).

Coder Bit Rate	RSVA	RSVB	RSVC
2400 bps	0	0	N/A
1200 bps	1	0	0
600 bps	0	1	N/A
Comfort Noise	1	0	1
(reserved)	1	1	N/A

Table 3.6 - MELPe Frame Bit Rate Indicators.

It is important to observe that senders have the following additional restrictions:

Senders SHOULD NOT include more MELPe frames in a single RTP packet than will fit in the MTU of the RTP transport protocol.

Frames MUST NOT be split between RTP packets.

It is RECOMMENDED that the number of frames contained within an RTP packet is consistent with the application. For example, in a telephony and other real time applications where delay is important, then the fewer frames per packet the lower the delay, whereas for

bandwidth constrained links or delay insensitive streaming messaging application, more than one or many frames per packet would be acceptable.

Information describing the number of frames contained in an RTP packet is not transmitted as part of the RTP payload. The way to determine the number of MELPe frames is to count the total number of octets within the RTP packet, and divide the octet count by the number of expected octets per frame (7/11/7 per frame). Keep in mind the last frame may be a 2 octet comfort noise frame.

When dynamic bit-rate switching is used and more than one frame is contained in a RTP packet, it is recommended to inspect the coder rate bits contained in the last octet. If the coder bit rate indicates a Comfort Noise frame, then inspect the third last octet for the coder bit rate. All MELPe speech frames in the RTP packet will be of this same coder bit rate.

3.4 Congestion Control Considerations

The target bitrate of MELPe can be adjusted at any point in time, thus allowing efficient congestion control. Furthermore, the amount of encoded speech or audio data encoded in a single packet can be used for congestion control, since the transmission rate is inversely proportional to the packet duration. A lower packet transmission rate reduces the amount of header overhead, but at the same time increases latency and loss sensitivity, so it ought to be used with care.

Since UDP does not provide congestion control, applications that use RTP over UDP SHOULD implement their own congestion control above the UDP layer [RFC5405]. Work in the RMCAT working group [rmcat] describes the interactions and conceptual interfaces necessary between the application components that relate to congestion control, including the RTP layer, the higher-level media codec control layer, and the lower-level transport interface, as well as components dedicated to congestion control functions.

4 Payload Format Parameters

This RTP payload format is identified using the MELP, MELP2400, MELP1200, and MELP600 media types which is registered in accordance with RFC 4855 [RFC4855] and using the template of RFC 6838 [RFC6838].

4.1 Media Type Definition

Type names:

audio

Subtype name:

MELP, MELP2400, MELP1200, and MELP600

Required parameters:

N/A

Optional parameters:

ptime, maxptime, bitrate

Encoding considerations:

This media type is framed and binary, see section 4.8 in RFC6838 [RFC6838].

Security considerations:

Please see the security considerations in section 8 of RFCxxxx (this RFC).

Interoperability considerations:

Early implementations used MELP2400, MELP1200, and MELP600 to indicate both coder type and bit rate. These media type names should be preserved with this registration.

Published specification:

N/A

Applications that use this media type:

N/A

Additional information:

N/A

Deprecated alias names for this type:

N/A

Magic number(s):

N/A

File extension(s):

N/A

Macintosh file type code(s):

N/A

Person & email address to contact for further information:

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Intended usage:

COMMON

Restrictions on usage:

This media type depends on RTP framing, and hence is only defined for transfer via RTP [RFC3550]. Transport within other framing protocols is not defined at this time.

Author:

Victor Demjanenko

Change controller:

IETF Payload working group delegated from the IESG.

Provisional registration? (standards tree only):

No

4.2 Mapping to SDP

The mapping of the above defined payload format media type and its parameters SHALL be done according to Section 3 of RFC 4855 [RFC4855].

The information carried in the media type specification has a specific mapping to fields in the Session Description Protocol (SDP) [RFC4566], which is commonly used to describe RTP sessions. When SDP is used to specify sessions employing the MELPe codec, the mapping is as follows:

- o The media type ("audio") goes in SDP "m=" as the media name.
- o The media subtype (payload format name) goes in SDP "a=rtpmap" as the encoding name.
- o The parameter "bitrate" goes in the SDP "a=fmtp" attribute by copying it directly from the media type string as "bitrate=value" or "bitrate=value1,value2" or "bitrate=value1,value2,value3".

When conveying information by SDP, the encoding name SHALL be "MELP" (the same as the media subtype). Alternative encoding name types, "MELP2400", "MELP1200", and "MELP600", may be used in SDP to convey fixed bit-rate configurations. These names have been observed in systems that do not support dynamic frame rate switching as specified by the parameter, "bitrate".

An example of the media representation in SDP for describing MELPe might be:

```
m=audio 49120 RTP/AVP 97
a=rtpmap:97 MELP/8000
```

An alternative example of SDP for fixed bit-rate configurations might be:

```
m=audio 49120 RTP/AVP 97 100 101 102
a=rtpmap:97 MELP/8000
a=rtpmap:100 MELP2400/8000
a=rtpmap:101 MELP1200/8000
a=rtpmap:102 MELP600/8000
```

If the encoding name "MELP" is received without a "bitrate" parameter, the fixed coder bit rate of 2400 MUST be used. The alternate encoding names, "MELP2400", "MELP1200", and "MELP600" directly specify the MELPe coder bit rate of 2400, 1200, and 600 respectively and MUST NOT specify a "bitrate" parameter.

The optional media type parameter, "bitrate", when present, MUST be

included in the "a=fmtp" attribute in the SDP, expressed as a media type string in the form of a semicolon-separated list of parameter=value pairs. The string, "value", can be one or more of 2400, 1200, and 600 separated by commas (where each bit-rate value indicates the corresponding MELPe coder). An example of the media representation in SDP for describing MELPe when all three coder bit rates are supported might be:

```
m=audio 49120 RTP/AVP 97
a=rtpmap:97 MELP/8000
a=fmtp:97 bitrate=2400,600,1200
```

Parameter ptime can not be used for the purpose of specifying MELPe operating mode, due to fact that for the certain values it will be impossible to distinguish which mode is about to be used (e.g. when ptime=68, it would be impossible to distinguish if packet is carrying 1 frames of 67.5 ms or 3 frames of 22.5 ms etc.).

Note that the payload format (encoding) names are commonly shown in upper case. Media subtypes are commonly shown in lower case. These names are case-insensitive in both places. Similarly, parameter names are case-insensitive both in media subtype name and in the default mapping to the SDP a=fmtp attribute

The value for "packet time" and "maximum packet time" parameters of the "ptime" and "maxptime" SDP attributes respectively, SHALL use the nearest rounded-up ms integer packet duration. For MELPe, this corresponds to the values: 23, 45, 68, 90, 112, 135, 156, and 180. Larger values may be used as long as they are properly rounded.

4.3 Declaritive SDP Considerations

For declaritive media, the "bitrate" parameter specifes the possible bit rates used by the sender. Multiple MELPe rtpmap values (such as 97, 98, and 99 as used below) may be used to convey MELPe coded voice at different bit rates. The receiver can then select an appropriate MELPe codec by using 97, 98, or 99.

```
m=audio 49120 RTP/AVP 97 98 99
a=rtpmap:97 MELP/8000
a=fmtp:97 bitrate=2400
a=rtpmap:98 MELP/8000
a=fmtp:98 bitrate=1200
a=rtpmap:99 MELP/8000
a=fmtp:99 bitrate=600
```

4.4 Offer/Answer SDP Considerations

In an Offer/Answer mode [RFC3264], "bitrate" is a bi-directional parameter. Both sides MUST use a common "bitrate" value or values. The offer contains the bit rates supported by the offerer listed in its preferred order. The answerer may agree to any bit rate by listing the bit rate first in the answerer response. Additionally the answerer may indicate any secondary bit rate or bit rates that it supports. The initial bit rate used by both parties SHALL be the first bit rate specified in the answerer response.

For example if offerer bit rates are "2400,600", and answer bit rates are "600,2400", the initial bit rate is 600. If other bit rates are provided by the answerer, any common bit rate between offer and answer may be used at any time in the future. Activation of these other common bit rates is beyond the scope of this document.

The use of a lower bit rate is often important for a case such as when one end point utilizes a bandwidth constrained link (e.g. 1200 bps radio link or slower), where only the lower coder bit rate will work.

5 Discontinious Transmission

A primary application of MELPe is for radio communications of voice conversations and discontinuous transmissions are normal. When MELPe is used in an IP network, MELPe RTP packet transmissions may cease and resume frequently. RTP SSRC sequence number gaps indicate lost packets to be filled by PLC while abrupt loss of RTP packets indicate intended discontinuous transmission.

If a MELPe coder so desires, it may send a comfort noise frame as per SCIP-210 Appendix B [SCIP210] prior to ceasing transmission. A receiver may optionally use comfort noise during its silence periods. No SDP negotiations are required.

6 Packet Loss Concealment

MELPe packet loss concealment (PLC) uses the special properties and coding for the pitch/voicing parameter of the MELPe 2400 bps coder. The PLC erasure indication may utilize any of the errored encodings of a non-voiced frame as identified in Table 1 of [MELPE]. For the sake of simplicity it is recommended to use a code value of 3 for the pitch/voicing parameter (represented by the bits P6 to P0 in Table 3.1). Hence, set bits P0 and P1 to one and bits P2, P3, P4, P5, and P6 to zero.

When using PLC in a 1200 bps or 600 bps mode, the MELPe 2400 bps decoder is called three or four times respectively to cover the loss of a MELPe frame.

7 IANA Considerations

This memo requests that IANA registers MELP, MELP2400, MELP1200, and MELP600 as specified in Section 4.1. The media type is also requested to be added to the IANA registry for "RTP Payload Format MIME types" (http://www.iana.org/assignments/rtp-parameters).

8 Security Considerations

RTP packets using the payload format defined in this specification are subject to the security considerations discussed in the RTP specification [RFC3550], and in any applicable RTP profile such as RTP/AVP [RFC3551], RTP/AVPF [RFC4855], RTP/SAVP [RFC3711] or RTP/SAVPF [RFC5124]. However, as "Securing the RTP Protocol Framework: Why RTP Does Not Mandate a Single Media Security Solution" [RFC7202] discusses, it is not an RTP payload format's responsibility to discuss or mandate what solutions are used to meet the basic security goals like confidentiality, integrity and source authenticity for RTP in general. This responsibility lays on anyone using RTP in an application. They can find guidance on available security mechanisms and important considerations in Options for Securing RTP Sessions [RFC7201]. Applications SHOULD use one or more appropriate strong security mechanisms. The rest of this security consideration section discusses the security impacting properties of the payload format itself.

This RTP payload format and the MELPe decoder do not exhibit any significant non-uniformity in the receiver-side computational complexity for packet processing, and thus are unlikely to pose a denial-of-service threat due to the receipt of pathological data. Nor does the RTP payload format contain any active content.

With respect to VAD and its effect on bit rate, please see security consideration in RFC6562 [RFC6562].

9 RFC Editor Considerations

Note to RFC Editor: This section may be removed after carrying out all the instructions of this section.

10 References

10.1 Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate

requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC4566] Handley, M., Jacobson, V. and Perkins, C., "SDP: Session Description Protocol", IETF RFC RFC4566, July 2006.

[RFC2736] Handley, M. and Perkins, C., "Guidelines for Writers of RTP Payload Format Specifications", BCP 36, RFC 2736, December 1999.

[RFC3264] Rosenberg, J. and Schulzrinne, H., "An Offer/Answer Model with the Session Description Protocol (SDP)" IETF RFC 3264, June 2002.

[RFC3550] Schulzrinne, H., Casner, S., Frederick, R. and Jacobson, V., "RTP: A Transport Protocol for Real-Time Applications", IETF RFC 3550, July 2003.

[RFC3551] Schulzrinne, H., and Casner, S., "RTP Profile for Audio and Video Conferences with Minimal Control" IETF RFC 3551, July 2003.

[RFC3711] Baugher, et al., "The Secure Real Time Transport Protocol", IETF RFC 3711, March 2004.

[RFC4855] Casner, S., "Media Type Registration of RTP Payload Formats", RFC 4855, February 2007.

[RFC5124] Ott, J. and Carrara, E., "Extended Secure RTP Profile for Real-time Transport Control Protocol (RTCP)-Based Feedback(RTP/SAVPF)", RFC 5124, February 2008.

[RFC5405] Westerlund, M. and Johansson, I., "RTP Payload Format for G.719", RFC 5405, January 2009.

[RFC6562] Perkins, C. and Valin, J. M., "Guidelines for the Use of Variable Bit Rate Audio with Secure RTP", RFC 6562, March 2012.

[RFC6838] Freed, N., Klensin, J. and Hansen, T., "Media Type Specifications and Registration Procedures", BCP 13, RFC 6838, January 2013.

10.2 Informative References

[MELP] Department of Defense Telecommunications Standard, "Analog-to-Digital Conversion of Voice by 2,400 Bit/Second Mixed Excitation Linear Prediction (MELP)", MIL-STD-3005, December 1999.

[MELPE] North Atlantic Treaty Organization (NATO), "The 600 Bit/S, 1200 Bit/S and 2400 Bit/S NATO Interoperable Narrow Band Voice

Coder", STANAG No. 4591, January 2006.

[SCIP210] National Security Agency, "SCIP Signaling Plan", SCIP-210, December 2007.

[RFC7201] Westerlund, M. and Perkins, C., "Options for Securing RTP Sessions", RFC 7201, April 2014.

[RFC7202] Perkins, C. and Westerlund, M., "Securing the RTP Framework: Why RTP Does Not Mandate a Single Media Security Solution", RFC 7202, April 2014.

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