COMMITTEE T1 – TELECOMMUNICATIONS
Working Group T1A1.7 **T1A1.7/99-016**
Boulder, CO; May 4 - 6, 1999

CONTRIBUTION

TITLE: **Results of a Subjective Listening Test for G.711 with Frame Erasure Concealment**

SOURCE*: **AT&T**

PROJECT: **T1A1-16, Interaction between the PSTN and other networks and terminals**
T1Q1-11, Specification of 4-kHz Voice and Voiceband Data Network Performance
T1Y1-28, Impact of Digital Techniques in Voice Networks

ABSTRACT

This contribution describes the results of a subjective listening test for G.711 with Frame Erasure Concealment (FEC). The FEC technique is described in contribution T1A1.7/99-012.

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1 Introduction

In another contribution (T1A1.7/99-012), we propose that T1A1 develop a standard for frame erasure concealment in packetized systems that use G.711 as the coding mechanism. In that contribution, we also describe extensions to Rec. G.711 that will make the codec robust for frame erasures (or packet loss). These extensions will make PCM more suitable for land-line packet transmission systems.

In this contribution, we provide the results of a subjective listening test. The test plan for this test is based on a similar test plan that was used to determine the performance of ITU-T Rec. G.728 Annex I for frame erasure and packet loss concealment. In the tests described here, we have included frame erasure rates up to 20%. The tests for Annex I to G.728 only included erasure rates up to 5%.

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2 Test Conditions

Forty-nine test conditions were used in the listening test. For each condition, six talkers (3 male and 3 female) were used. Test conditions are conveniently grouped into "G.711 conditions" and "Reference Conditions."

2.1 G.711 Conditions

For all G.711 conditions, a frame size of 10 ms was used. Frame erasures occurred either at random or in bursts and erasure rates of 1%, 3%, 5%, 7%, 10%, 15%, and 20% (resulting in thirteen error rates). Each of these G.711 conditions was tested with input levels of -36, -26, and -16 dBov.

2.2 Reference Conditions

In addition to G.711 test conditions, 24 reference conditions are included:

— six MNRU conditions;

— the “direct” condition;

— one G.726 (ADPCM) condition;

— seven G.728 conditions, clear, 1%, 3%, 5% RFER and BFER;

— seven G.729 conditions, clear, 1%, 3%, 5% RFER and BFER.

3 Processing of Source Material

All speech materials was processed using the ITU–T STL (Software Tools Library).

4 Test Procedures

The subjective evaluation used the Absolute Category Rating (ACR) method as defined in ITU–T Rec. P.800. Additional information on subjective evaluation of speech codecs is available in ITU–T Rec. P.830.

Forty-three listeners participated in the evaluation

5 Results

Summary results are shown in Table 1. Mean Opinion Score (MOS) for Random Frame Erasure conditions is plotted in Fig.1. Similarly, Fig. 2 shows MOS for Bursty Frame Erasure conditions. Fig. 3 shows MOS for Random and Bursty erasure conditions (for G.711 only) plotted on the same set of axes for easy comparison.

Criteria for performance of codecs under error conditions have been under discussion in ITU-T SG12 for some time. Originally, the criterion was for the MOS of a codec under 3% errors to be no more the 0.5 lower than the MOS for G.726 under error-free conditions. More recently, the criterion has been expressed in terms of the percentage Poor-or-Worse judgements, in which case the %PoW of the codec under 3% errors should be no more than ten points higher than that of G.726 under error-free conditions. By either measure, G.711 with the frame erasure concealment method described in T1A1.7/99-012 is a clear success. Moreover, when frame erasures are random, a fairly high level of performance is maintained for error rates as high as 7%.

6 Conclusions

No packet loss protection method can be expected to achieve the high quality performance present in error-free conditions. However, this new method for frame erasure concealment with G.711 has been demonstrated to provide high quality error protection for error rates up to about 7%. Moreover, for packet loss rates up to 20%, performance degrades gracefully, even under the stress of bursty frame erasures.

Table 1: Summary of Test Results

Condition		Frame Loss (Rate & Type)	Input level	MOS	%E	%G	%F	%P	%B
C00	Direct	-	-26 dBov	4.186	36	48	15	1	0
C01	MNRU, Q = 6 dB	-	-26 dBov	1.632	0	1	6	47	45
C02	MNRU, Q = 12 dB	-	-26 dBov	2.453	2	5	38	45	10
C03	MNRU, Q = 18 dB	-	-26 dBov	3.438	10	37	41	10	2
C04	MNRU, Q = 24 dB	-	-26 dBov	3.938	25	48	24	3	0
C05	MNRU, Q = 30 dB	-	-26 dBov	4.155	36	47	14	2	0
C06	MNRU, Q = 36 dB	-	-26 dBov	4.155	35	47	18	1	0
C07	32 kbit/s G.726	0	-26 dBov	3.868	23	43	31	3	0
C08	16 kbit/s G.728	0	-26 dBov	4.012	26	51	20	3	0
C09	16 kbit/s G.728	1% RFER	-26 dBov	3.764	16	50	29	5	0
C10	16 kbit/s G.728	1% BFER	-26 dBov	3.578	12	46	32	9	2
C11	16 kbit/s G.728	3% RFER	-26 dBov	3.438	10	37	41	12	0
C12	16 kbit/s G.728	3% BFER	-26 dBov	3.453	10	40	37	13	1
C13	16 kbit/s G.728	5% RFER	-26 dBov	2.946	3	27	37	29	5
C14	16 kbit/s G.728	5% BFER	-26 dBov	2.857	8	26	28	22	17
C15	8 kbit/s G.729	0	-26 dBov	3.934	25	47	25	3	0
C16	8 kbit/s G.729	1% RFER	-26 dBov	3.721	16	47	31	6	0
C17	8 kbit/s G.729	1% BFER	-26 dBov	3.636	12	48	30	9	0
C18	8 kbit/s G.729	3% RFER	-26 dBov	3.492	10	41	38	10	1
C19	8 kbit/s G.729	3% BFER	-26 dBov	3.597	14	42	35	9	1
C20	8 kbit/s G.729	5% RFER	-26 dBov	3.058	3	28	43	24	2
C21	8 kbit/s G.729	5% BFER	-26 dBov	2.973	6	27	32	27	8

Table 1 (cont.): Summary of Test Results

Condition		Frame Loss (Rate & Type)	Input level	MOS	%E	%G	%F	%P	%B
C22	64 kbit/s G.711	0	-26 dBov	4.140	34	49	15	2	0
C23	64 kbit/s G.711	1% RFER	-26 dBov	4.093	29	53	15	2	0
C24	64 kbit/s G.711	1% BFER	-26 dBov	3.946	24	52	19	4	1
C25	64 kbit/s G.711	3 % RFER	-26 dBov	3.853	19	51	26	3	0
C26	64 kbit/s G.711	3 % BFER	-26 dBov	3.926	26	48	20	6	0
C27	64 kbit/s G.711	5 % RFER	-26 dBov	3.915	22	53	20	5	0
C28	64 kbit/s G.711	5 % BFER	-26 dBov	3.329	12	36	30	15	6
C29	64 kbit/s G.711	7 % RFER	-26 dBov	3.802	19	46	33	2	1
C30	64 kbit/s G.711	7 % BFER	-26 dBov	3.089	5	28	39	25	2
C31	64 kbit/s G.711	10 % BFER	-26 dBov	3.477	9	41	37	12	0
C32	64 kbit/s G.711	10% BFER	-26 dBov	2.547	2	15	35	34	15
C33	64 kbit/s G.711	15% RFER	-26 dBov	3.016	3	29	36	28	3
C34	64 kbit/s G.711	15% BFER	-26 dBov	2.310	1	8	34	34	22
C35	64 kbit/s G.711	20% RFER	-26 dBov	2.465	2	12	30	45	12
C36	64 kbit/s G.711	20% BFER	-26 dBov	1.942	1	7	16	40	37
C37	64 kbit/s G.711	3 % RFER	-36 dBov	4.016	25	53	22	1	0
C38	64 kbit/s G.711	3 % BFER	-36 dBov	4.012	26	51	21	2	0
C39	64 kbit/s G.711	7 % RFER	-36 dBov	3.775	15	53	26	5	0
C40	64 kbit/s G.711	7 % BFER	-36 dBov	3.027	5	28	37	27	3
C41	64 kbit/s G.711	15% RFER	-36 dBov	3.031	3	29	42	21	5
C42	64 kbit/s G.711	15% BFER	-36 dBov	2.283	1	7	33	38	22
C43	64 kbit/s G.711	3 % RFER	-16 dBov	3.919	22	51	25	2	0
C44	64 kbit/s G.711	3 % BFER	-16 dBov	3.969	26	49	20	4	0
C45	64 kbit/s G.711	7 % RFER	-16 dBov	3.818	17	52	26	5	0
C46	64 kbit/s G.711	7 % BFER	-16 dBov	2.977	6	25	35	29	5
C47	64 kbit/s G.711	15% RFER	-16 dBov	3.109	4	33	36	22	4
C48	64 kbit/s G.711	15% BFER	-16 dBov	2.399	1	12	31	38	18

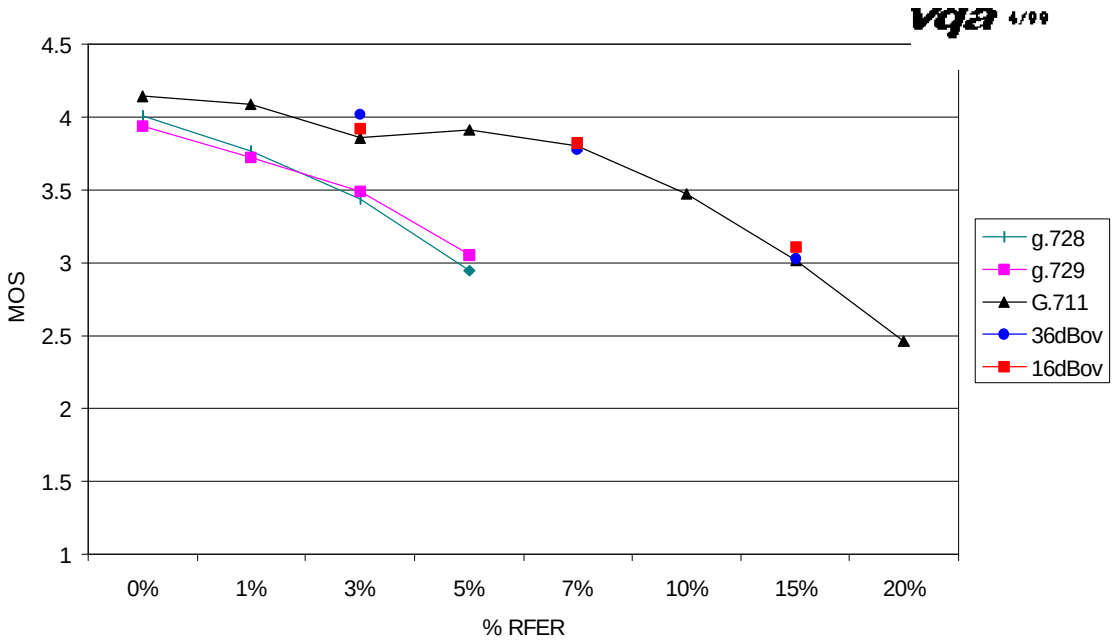

Figure 1: Mean Opinion Score (MOS) as a function of error rate for random frame erasure conditions.

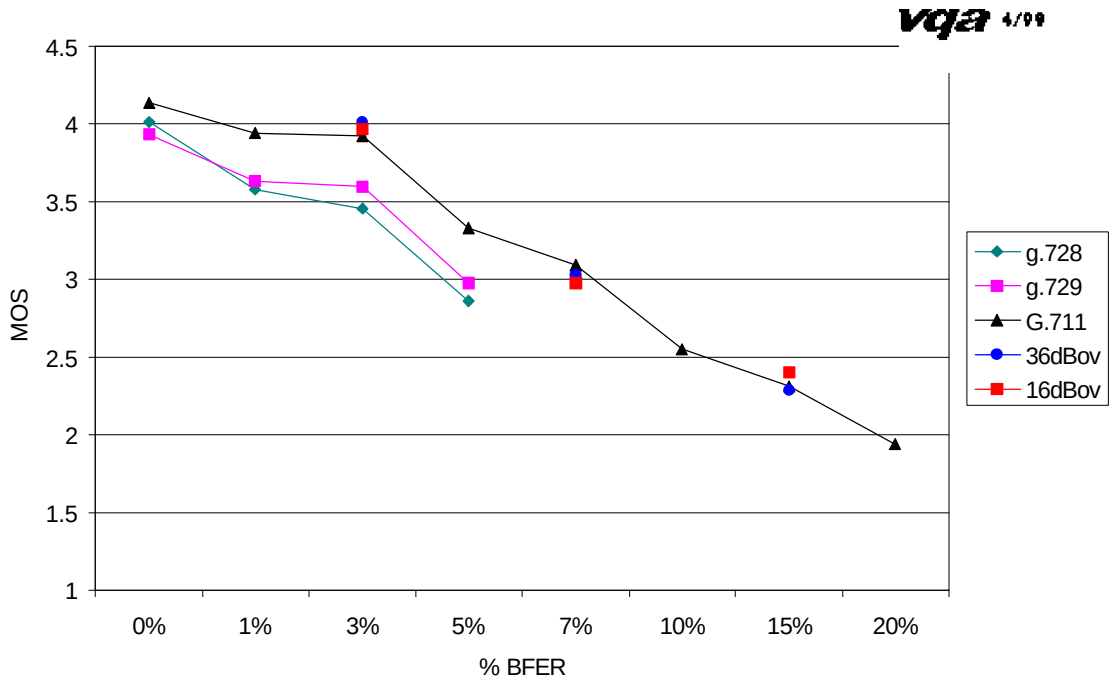

Figure 2: Mean Opinion Score (MOS) as a function of error rate for bursty frame erasure conditions.

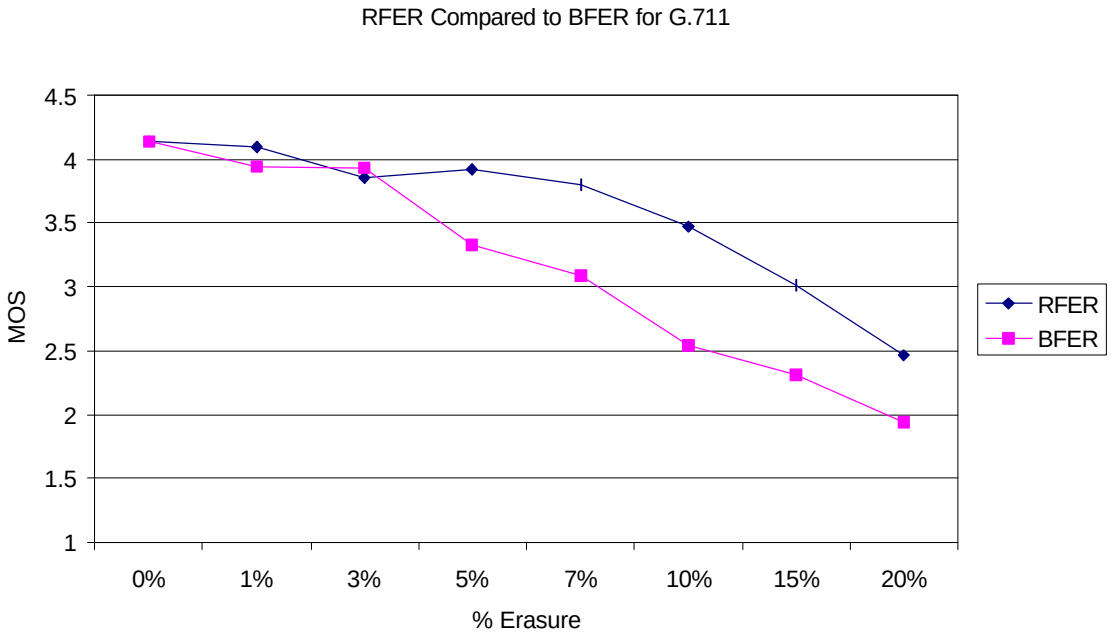

Figure 3: Comparison of MOS for random and bursty erasures as a function of error rate.