

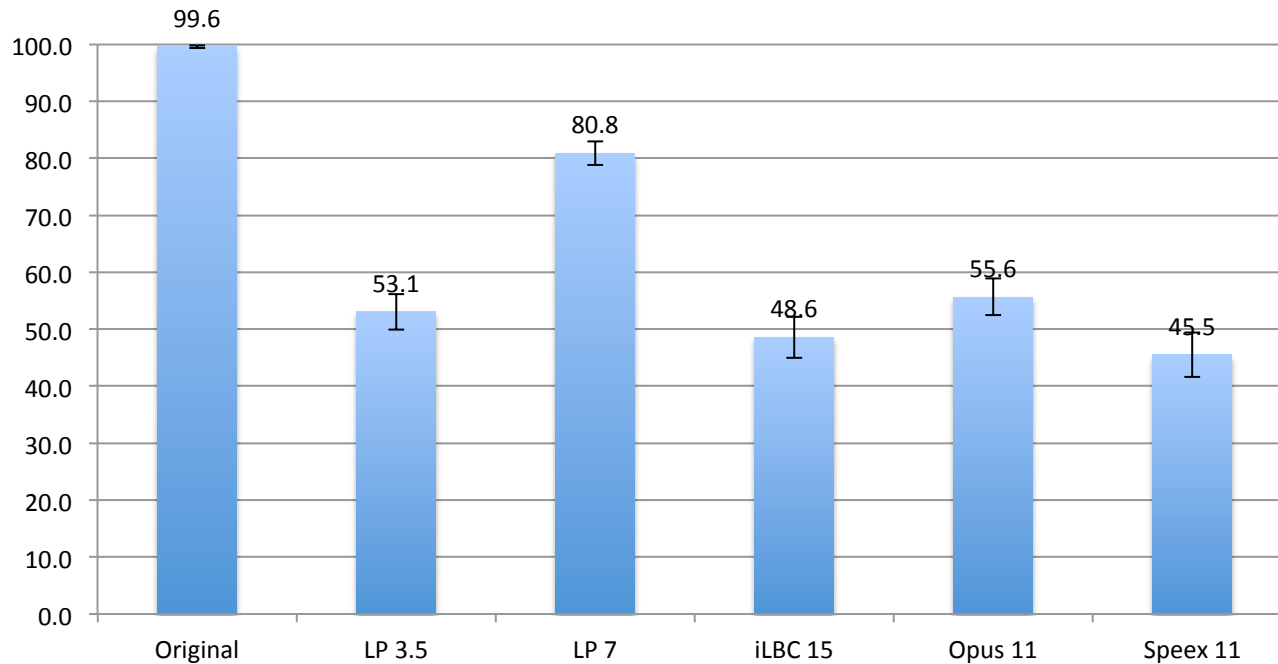
Introduction

- Three MUSHRA-type tests performed in March 2011 at Google
- Both trained and untrained listeners
- Tests presented on Windows PC with headphones

Test 1 – Narrowband Mono Speech

- 3 different male and 3 different female speakers
- Reference files sampled at 48 kHz in low background noise
- 2 anchors: lowpass-filtered at 3.5 kHz and 7.0 kHz
- 17 listeners, no post-screening
- 3 narrowband codecs, all using 20 ms frames
 - iLBC at 15.2 kbps, constant bit rate
 - Speex NB at 11 kbps, constant bit rate
 - Opus NB at 11 kbps, variable bit rate

Overall Results – Narrowband Speech

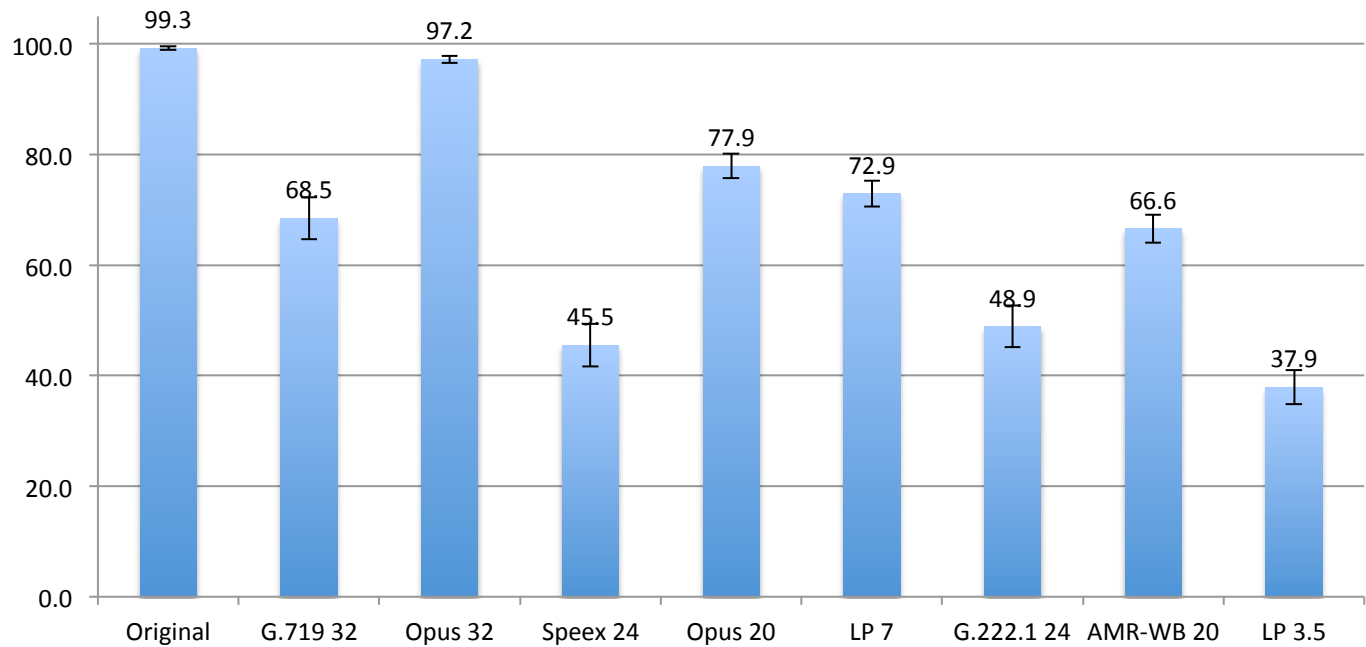


Opus at 11 kbps is better than iLBC at 15 kbps and Speex at 11 kbps

Test 2 – Wideband and Fullband Mono Speech

- 3 different male and 3 different female speakers
- Reference files sampled at 48 kHz in low background noise
- 2 anchors: lowpass-filtered at 3.5 kHz and 7.0 kHz
- 17 listeners, no post-screening
- 4 wideband codecs, all using 20 ms frames
 - G.722.1 at 24 kbps, constant bit rate
 - Speex WB at 23.8 kbps, constant bit rate
 - Opus WB at 19.85 kbps, variable bit rate
 - AMR-WB at 19.85 kbps, constant bit rate
- 2 fullband codecs, both using 20 ms frames
 - G.719 at 32 kbps, constant bit rate
 - Opus FB at 32 kbps, constant bit rate

Overall Results - Fullband and Wideband Speech



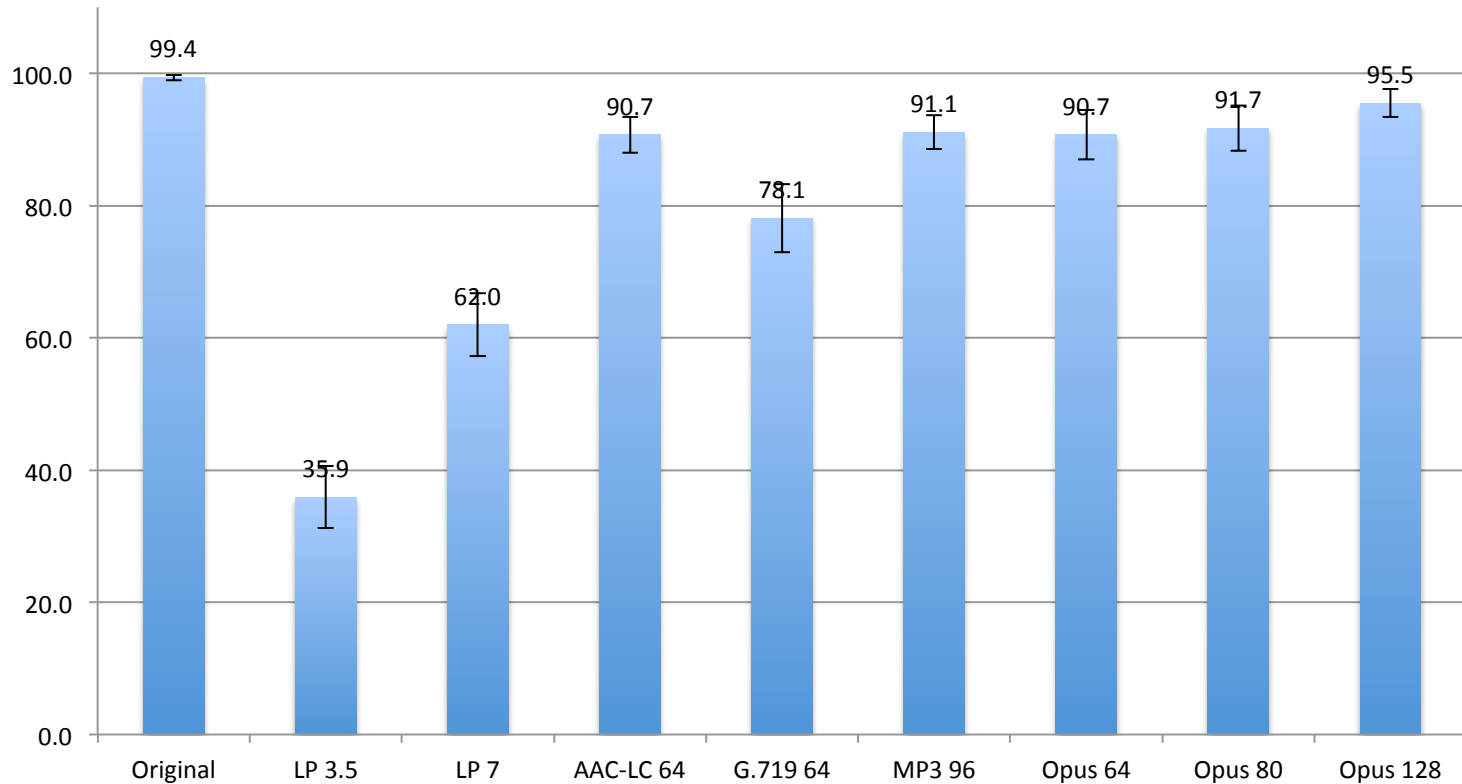
Opus at 32 kbps is almost transparent

Opus at 20 kbps is better than LP filtered speech at 7 kHz

Test 3 – Fullband Stereo Music

- 10 stereo music files
 - Rock/R&B (Boz Scaggs)
 - Soft rock (Steely Dan)
 - Rock (Queen)
 - Jazz (Harry James Orchestra)
 - Classical (Purcell String Piece)
 - Electronica (Matmos)
 - Piano (Moonlight Sonata)
 - Vocals (Suzanne Vega)
 - Glockenspiel
 - Castanets
- Reference files sampled at 48 kHz and 44.1 kHz
- 2 anchors: lowpass-filtered at 3.5 kHz and 7.0 kHz
- 9 listeners, no post-screening
- 6 codecs
 - AAC-LC (Nero) at 64 kbps, 21 ms frame size, constant bit rate (bit reservoir)
 - G.719 at 64 (2 x 32) kbps, 20 ms frame size, constant bit rate
 - MP3 (Lame) at 96 kbps, <100 ms, constant bit rate
 - Opus at 64 kbps, 20 ms frame size, constrained variable rate
 - Opus at 80 kbps, 10 ms frame size, constrained variable rate
 - Opus at 128 kbps, 5 ms frame size, constrained variable rate

Overall Results Fullband Stereo Music



Opus (at 64 kbps/20ms, 80 kbps/10 ms, and 128 kbps/5 ms)
is

equal in quality to MP3 at 96 kbps
equal in quality to AAC-LC at 64 kbps
better than G.719 at 64 kbps