GLOBAL IP SOUND

Professional Services – VoIP Sound Quality Assessment

Acoustic Echo Cancellation in IP Phones

Fall 2003

Sound Quality Evaluation: Acoustic Echo Cancellation

Introduction

Although acoustic echo cancellation (AEC) is usually seen as a feature among the rest, the quality implication of a bad performing echo canceller is enormous. Half duplex echo suppressors have been used since the introduction of long-distance communication, but due to their limitations in handling voice clipping, background noise and double talk, most business applications are today using adaptive echo cancellers instead. The adaptive echo cancellers use a different approach to deal with the non-linear and non-stationary echo. Rather than try to physically isolate echo paths, an echo canceller attempts to predict what an echo will be and to generate a replica of the echo that it then subtracts from the signal.

At its most general, a good echo canceller must:

- Remove echo quickly at the start of a call, as well as prevent any form of echo during the call
- Handle double talk without echo or voice clipping at the beginning or end of a double talk voice spurt
- Dynamically track echo path changes
- Handle background noise, including both high and variable background noise

Objectives

As voice over IP (VoIP) is emerging as a viable alternative to PSTN (public switched telephony networks) the performance of VoIP devices is expected to match that of traditional PSTN equipment. Global IP Sound selected five commercially available hands-free-capable IP phones to perform a series of subjective evaluations of the overall and specific aspects of quality related to acoustic echo cancellation. The goal was to evaluate the performance and quality of acoustic echo cancellation in currently available IP phones made by major vendors and to determine whether or not major brand VoIP phone could perform as well as typical PSTN speaker phones – a feature added in more IP phones as adoption of VoIP steadily increases within small to large businesses and enterprise environments.

The subjective tests assessed how each of the five phones handled three aspects of acoustic echo, which individually and in combination affect the overall usability of a hands-free phone:

- echo
- background noise
- clipping

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Summary of Findings

Overall, the AEC test showed that most phones were able to address the effects of acoustic echo, but were inconsistent in how they handled background noise and clipping, which affected the overall perceived quality.

The table below summarizes lowest and highest results from the different test cases. Some test cases were divided into several test scenarios.

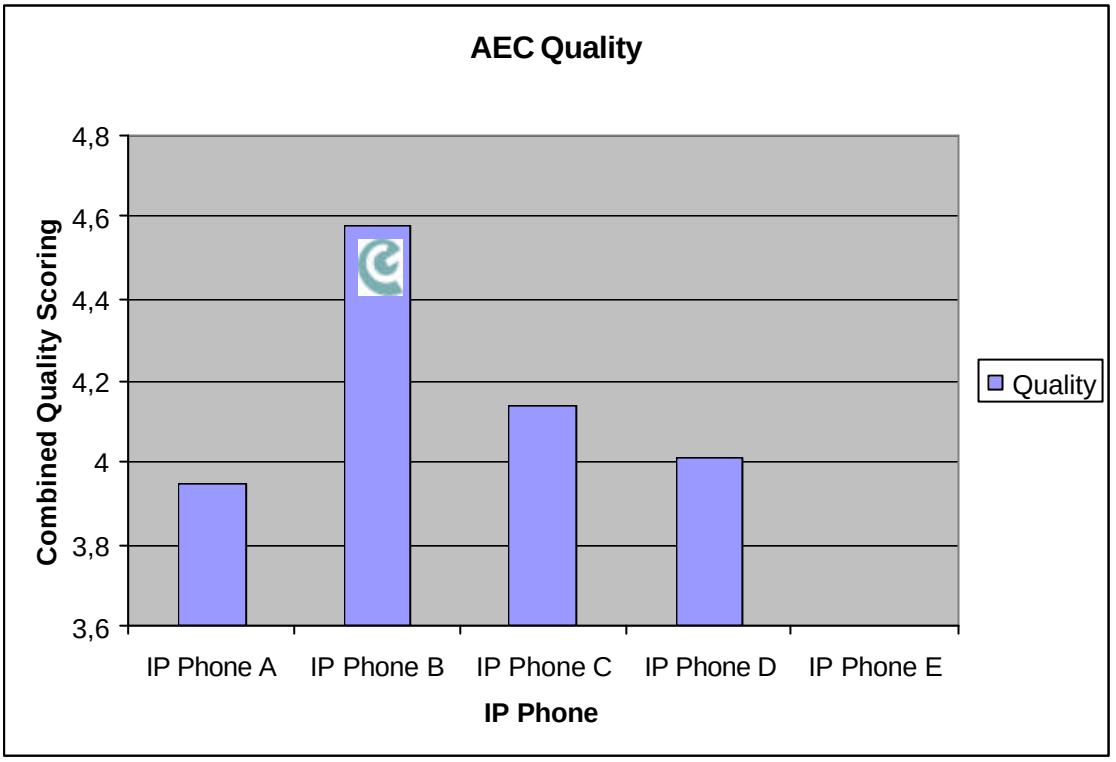
Test Case		Scoring	
		Lowest	Highest
Single Talk	Echo	4.2	5.0
	Clipping	4.7	5.0
	Noise	3.0	4.8
Fast Switching	Echo	4.7	5.0
	Clipping	3.7	4.8
	Noise	2.7	4.8
Double Talk	Echo	4.7	4.9
	Clipping	2.3	4.7
	Noise	2.7	4.8
Level Sensitivity	Echo	4.3	5.0
	Clipping	1.7	4.8
	Noise	2.6	5.0
Overall Conversation	Echo	4.3	4.8
	Clipping	2.7	4.6
	Noise	2.5	4.9

The reason that some phones scored very high on echo cancellation and low on clipping and background noise, could be a result of the fact that AEC technologies have traditionally been designed as a switch (half-duplex) to work only when speakers are talking one at the time, making it inappropriate as a business conferencing solution

The challenge of creating a good acoustic echo canceller is to be able to deal with echo, background noise and double talk. Differences in the background noise during silence and while speaking can be very disturbing. An example of this is absence of background noise that leads to that the users think that the line is dead. Bad implementations of double talk detectors will lead to excessive clipping or excessive acoustic echo, if the double talk “thresholds” are set too low. When clipping is present you will loose words, and the discussion will be more as a walkie-talkie conversation.

To create a combined scoring that reflects the overall perceived quality, the scoring from each test case was, for each IP phone, weighted between the test cases. The single talk scenarios were weighted 85% compared to the double talk scenarios (15%). The three resulting scores were then weighted between echo (50%), background noise (25%) and clipping (25%) to obtain a combined scoring.

The following chart shows how each of the five phones performed in combating acoustic echo – combined results for echo, background noise and clipping.



Scoring: 5=Excellent, 4=Good, 3=Fair, 2=Poor, 1=Bad

The major difference between Phone B, C and D, was that Phone B showed exceptional clipping and background noise results. Phone B was equipped with GIPS AEC-IP Phone software.

Phone E scored so poorly in all AEC areas that it was excluded from the test early in the process.

In summary, although four of the five phones performed well on canceling the echo, only one phone out-performed the others by dealing with all aspects of a hands-free IP phone. This phone, with embedded GIPS AEC-IP Phone software, delivered the highest quality sound, making it the ideal solution, for today's conferencing IP phones in small to large businesses and enterprises.

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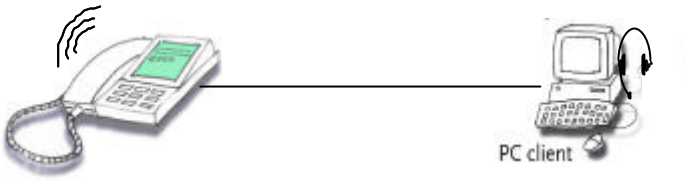
Test Information

Test setup

A soft client with headset was used on one side (far end) and on the other side (near end) an IP Phone operating in handsfree/speakerphone mode was used. Both sides connected through a "perfect" LAN environment, peer-to-peer with no packet loss or delay, which ensured the same network conditions for all five tests. Furthermore, the G.711 codec was used in all test cases.



The IP Phones were set-up in a 14.8 ft. by 8.2 ft. (4.5 x 2.5 meter) enclosed office with normal background noise.

Test Methodology

Both expert and naïve listeners performed the evaluation to get a broad subjective result. Each person spent approximately 30 minutes on each IP Phone listening for the different test cases.

The listeners were using the same soft phone on the "far end" and all test scenarios were performed as blind tests (i.e. the listener did not know which IP phones were being used on the other end).

Evaluation Criteria

The following test cases were evaluated for each IP phone:

- Single talk – Initial behavior
- Single talk – Steady state
- Fast Switching
- Double talk - Partial overlap
- Double talk – Full overlap
- Level sensitivity (with different voice, recording and speaker volumes on both sides)
- Overall – 15 minutes conversation

For each test case, perceived quality was given a score between one and five based on how well the IP phone handled:

- Echo
- Background noise
- Clipping

Scores were given accordingly:

Grade	Echo	Background Noise	Clipping
5	Perfect, no echo at all	Perfect, same background noise as during silence	No clipping, the both side are clear at all time
4	Sometimes-audible echo but still but not disturbing	Sometimes fluctuations in the background noise are detected. These fluctuations, that are not present in the background noise during silence, are not disturbing	Sometimes very small parts of words are missing but not disturbing
3	Sometimes the echo is disturbing but most of the time it is not	Sometimes fluctuations in the background noise are detected. These fluctuations, that are not present in the background noise during silence, are disturbing	A word is sometimes missing but most of the time ok
2	Loud echo that eventually disappears	Clear, disturbing, difference between the background noise during silence and the background noise while speaking	Very hard to have a conversation, lots of words are not audible
1	Loud echo that does not go away	Very disturbing noise at all times	Not possible to hear the other side at all

About Global IP Sound

Global IP Sound develops voice-processing technologies for real-time communications on packet networks that result in better than cellular/PCS and PSTN calls. The company's codecs and algorithms are embedded into soft phones, IP phones, and gateways to overcome delay, jitter, packet loss, and acoustic and network echo. The increased quality and robustness enable the confident deployment of "traditional" VoIP and today's newer applications, including voice over WiFi and multi-user conferencing.

In addition to subjective evaluations, Global IP Sound's professional services also perform full G.167 or G.168 tests.

For additional information, please contact:

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