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Teraquant Corporation

- HQ Boulder, Colorado
- Founded: 2001
- Perceptual Metrics experience since 1993
- Oracle’s only OEM adding functionality to Palladion/OCOM Service assurance/Monitoring platform
  - Eg TLS & SRTP Analysis and decryption for troubleshooting
- Providing test & troubleshooting, SBC, IP PBX Solutions and services nationwide & internationally.
- work with many Industry leaders on VQM (MOS, PESQ & POLQA)

Web: www.teraquant.com
Agenda

► Problem Landscape
► MOS : Definition
► Troubleshooting with R Factor/E-Model
► Audio Perceptual Metrics
► Impairments Detectable at Audio Layer
► Test System Deployment Scenarios
Problem Landscape

• Complex Architectures:
  • Telephony (transcoding, compression, Voice Activation Detection, Auto Gain Control, Packet Loss Concealment, ...)
  • Subscriber network – QoS, broadband, SD WAN
  • Service Provider Network (ISDN, IP, POTS, Analog, wireless cellular/Wi-Fi ...)
  • Transcoding (media gateways)

• Impairments
  • Latency
  • Jitter
  • Packet loss
  • Compression of voice signal
  • Codec running on different hardware footprints

• Symptoms
  • Satellite dialog effect (delays cause people to interrupt each other)
  • VAD, Time Clipping, One-way audio, speech loss
  • Level control is limited: attenuation or high gain Amplitude Clipping to saturate speakers
  • Echo
  • Noise
  • ...
2 Categories of Impairment Impacting Voice Quality

LAN with no load. Speech quality moderate

Network with data load. Speech quality poor. Packet/frame loss visible as negative excursions in the error surface. Loss of synchronisation near end produces loud 'squeak' effect
MOS - Leading Indicator of Call Quality

- Subjective measurement
  - Based on subjective experiments
  - Mean Opinion Score
  - “Gold Standard” – but...
  - Costly and time consuming

- Objective measurement
  - Must have Good correlation with subjective measurement
  - Highly repeatable
  - Real-time
  - “MOS” usually taken to mean “MOS-LQ”

- ITU-T P.800
  - Methods for subjective determination of transmission quality

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5 Excellent
4 Good
3 Fair
2 Poor
1 Bad

Imperceptible
Just perceptible but not annoying
Perceptible and slightly annoying
Annoying but not objectionable
Very annoying and objectionable
# Objective MOS Algorithms and High Definition Voice

<table>
<thead>
<tr>
<th>Name</th>
<th>Standard</th>
<th>Layer</th>
<th>Monitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-model/R-factor</td>
<td>ITU-T Recommendation G.107</td>
<td>Packet</td>
<td>Passive</td>
</tr>
<tr>
<td>Perceptual Evaluation of Speech Quality (PESQ)</td>
<td>ITU-T Recommendation P.862.1 for narrow-band codecs (3.1KHz).</td>
<td>Audio</td>
<td>Active</td>
</tr>
<tr>
<td>Perceptual Objective Listening Quality Analysis (POLQA)</td>
<td>ITU-T Recommendation P.863 for narrow &amp; Wide band codecs (24KHz).</td>
<td>Audio</td>
<td>Active</td>
</tr>
</tbody>
</table>
Measuring MOS at “Audio” layer via Analog Interfaces
E-model: MOS for High-Volume Operational IP Transport Networks [Passive, Non-Intrusive and Operates on User Data]
Passive Monitoring at Each Network Segment Allows Physical Isolation of Packet Impairment Problem
Detection of One-Way Audio

<table>
<thead>
<tr>
<th>State</th>
<th>Audio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Established</td>
<td>No audio</td>
</tr>
<tr>
<td>Proceeding</td>
<td>One way audio</td>
</tr>
<tr>
<td>Finished</td>
<td>No audio</td>
</tr>
<tr>
<td>Proceeding</td>
<td>One way audio</td>
</tr>
<tr>
<td>Ringing</td>
<td>No audio</td>
</tr>
<tr>
<td>Established</td>
<td>OK</td>
</tr>
<tr>
<td>Ringing</td>
<td>No audio</td>
</tr>
<tr>
<td>Proceeding</td>
<td>One way audio</td>
</tr>
<tr>
<td>Established</td>
<td>OK</td>
</tr>
<tr>
<td>Failed</td>
<td>No audio</td>
</tr>
<tr>
<td>Established</td>
<td>No audio</td>
</tr>
<tr>
<td>Established</td>
<td>OK</td>
</tr>
<tr>
<td>Redirected</td>
<td>Multi...</td>
</tr>
<tr>
<td>Finished</td>
<td>OK</td>
</tr>
<tr>
<td>Finished</td>
<td>OK</td>
</tr>
<tr>
<td>Failed</td>
<td>No audio</td>
</tr>
</tbody>
</table>
The phone can bring distortion (noise, AEC, AGC, ..) to final speech signal
Voice Quality: Root Cause Categories

• Recognize the different causes of speech quality problems
  1. Packet loss and jitter
  2. Audio impairments
     • Codec overload
     • loss of synchronization
     • transcoder error
     • Endpoint failure or CPU congestion
  3. Delay & echo are NOT represented in MOS
Audio Exhibits Packet Loss

‘PacketLoss.wav’
Softphone Test Case

WebRTC

Softphone

e.g.: WebRTC

Access to Corporate IP Network

WebRTC termination to SIP Interface

SIP Trunks to PSTN

SBC

Hardphone Desk Enterprise

www.teraquant.com
softphone Starved of CPU

Female 1 - REF

Female 1 - Degraded

Male 1 - REF

Male 1 - Degraded