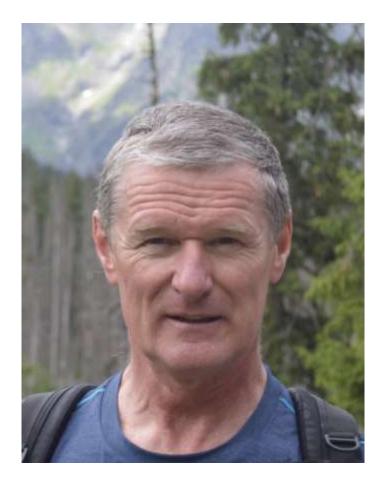
Telecom Technology Solutions



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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* products and services nationwide & internationally.
- work with many Industry leaders on VQM (MOS, PESQ & POLQA)

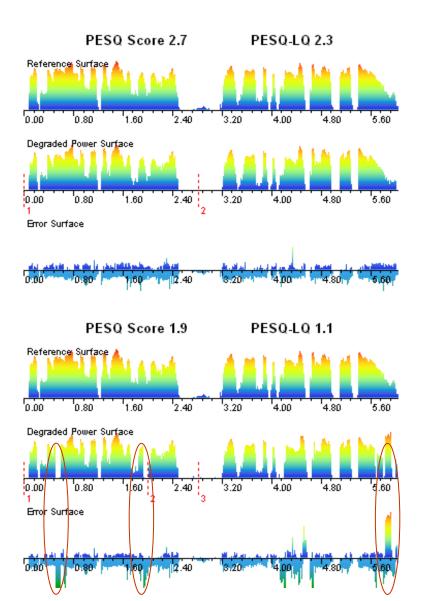




Agenda

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

2 Categories of Impairment Impacting Voice Quality



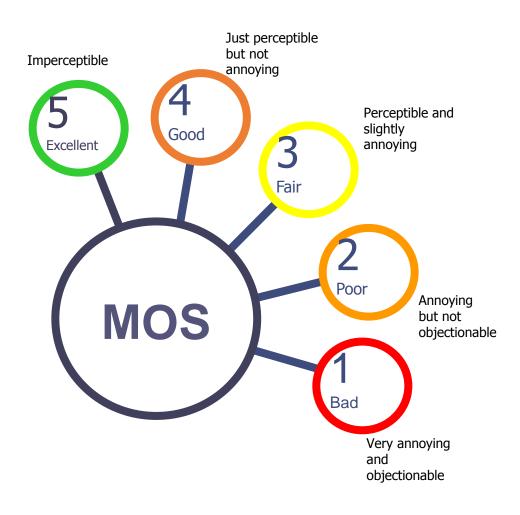
LAN with no load. Speech quality moderate



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



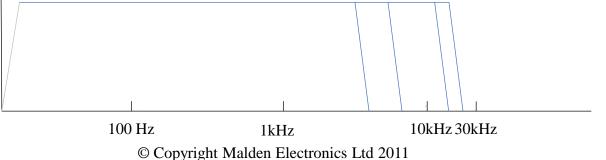
MOS - Leading Indicator of Call Quality



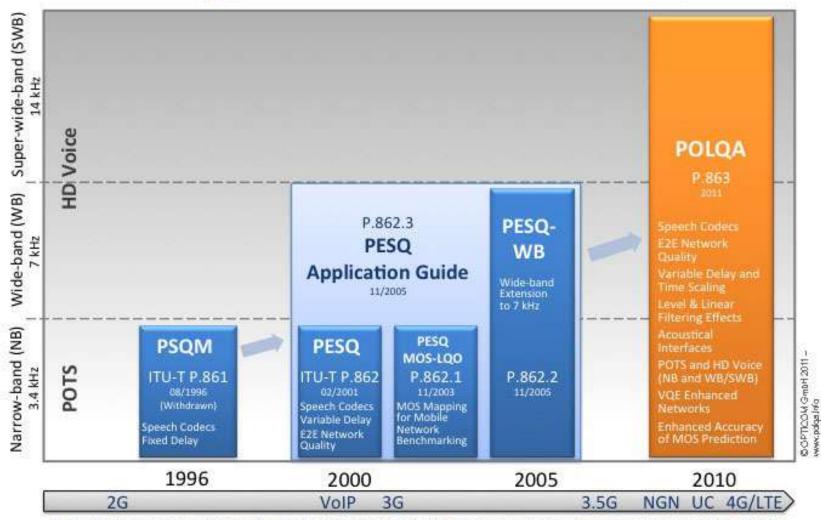
- Subjective measurement
 - Based on subjective experiments
 - Mean Opinion Score
 - "Gold Standard" but...
 - Costly and time consuming
- Objective measurement
 - Must have Good correlation with subjective measurement
 - Highly repeatable
 - Real-time
 - "MOS" usually taken to mean "MOS-LQ"
- ITU-T P.800
 - Methods for subjective determination of transmission quality

Types of Objective Measurements

Name	Standard	Layer
E-model/R-factor	ITU-T Recommendation G.107	Packet
Perceptual Evaluation of Speech Quality (PESQ)	ITU-T Recommendation P.862.1 for narrow-band codecs (3.1KHz).	Audio
Perceptual Evaluation of Speech Quality (WB-PESQ)	ITU-T Recommendation P.862.2 for narrow-band codecs (7KHz).	Audio
Perceptual Objective Listening Quality Analysis (POLQA)	ITU-T Recommendation P.863 for narrow-band codecs (24KHz).	Audio
	· ·	



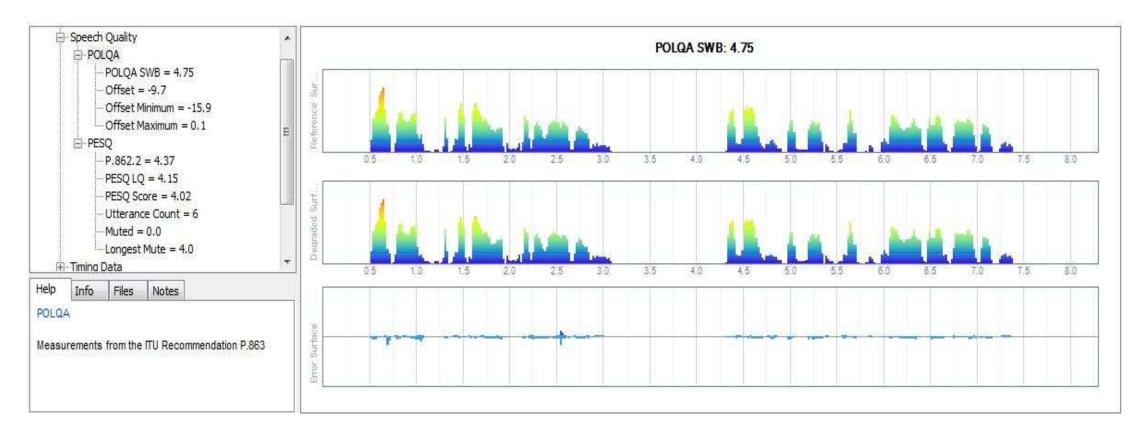
Evolution of ITU-T Recommendations for Voice Quality Testing (P.86x - Full Reference MOS-LQO)



Evolution of Network Technologies available at the time of development, i.e. included use cases for each Recommendation

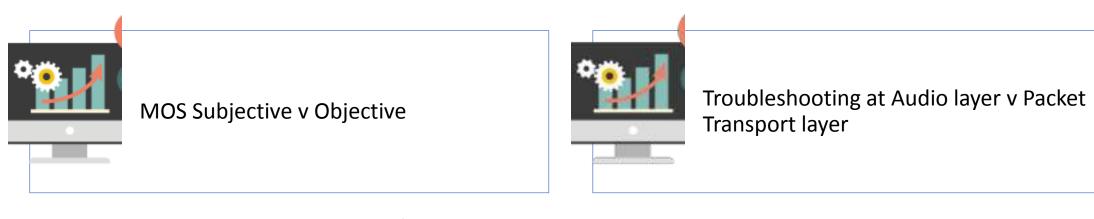
POLQA Solutions

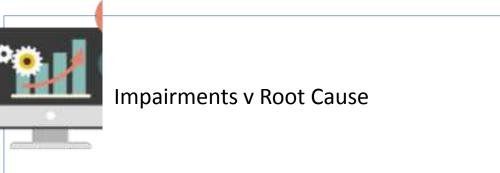
Time Warping



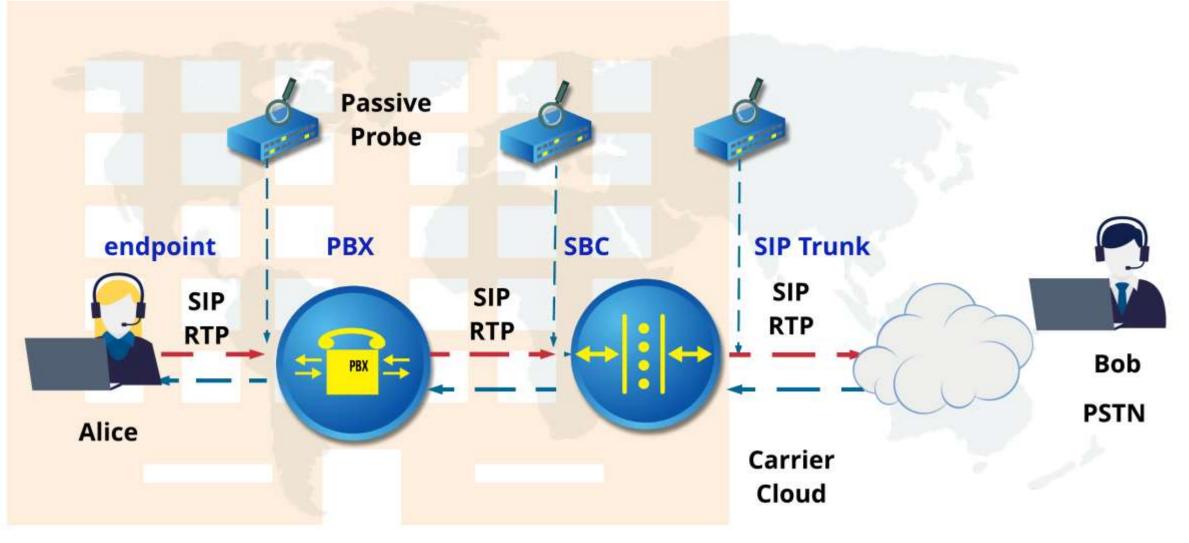
© Copyright Malden Electronics Ltd/Opale System 2011

Agenda





E-model: MOS for High-Volume Operational IP Transport Networks [Passive, Non-Intrusive and Operates on User Data]



BRANCH

Passive Monitoring at Each Network Segment Allows Physical Isolation of Packet Impairment Problem

all Info														
Ringin			/14 12:45	::12										
egments	Media Su	mmary	Media	Details	Message	85								
12:45	5:10		12:4	5:40		12:	46:10		12:46:40	12:47:10				
0		4.34	2.54	1.08	4,6	1	1.33	1.33	-436			1		
1		4.41	441	441	4.41	42	2.13	9.41	4.41	20.30 22:46	Call Info (* @1.8)	22.45 2	13 80 21	3.15
2		4.41	4.41	3661	0.41	4.41	488.	4.44	4.41	Hinda Nadmum Hinda (493058912758 → 499958912758			
3		441	4.15	4.28	441	4.05	1.99	4.38	4.32	Chrow Intervel in Grid	Rinaland Setup start time: 2017/02/14-23:12:08 Bloging time: 2'Ums	Zoom: See 20m 1h 3h	Rh 1d 3d 7d 3Dd	m-):
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		10.00	1.00					10.000		Real calls	Segnerta Media Summary Media Detalla Messages			-
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_										Caller IP address Start timestamp	Packets discarded 0 Packets lost 0	grees device(s)		we MOS
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										192.168.119.69 2017-02-14 23:12:18	1/2.10.1.6/04381 10.9.0.1/643/9	dunich	1.30	31
										192,168,119,68 2017-02-14 23,12:18	Reporter OCOM-RTP-PROBE	aurich	1.30	3.5
										192, 168, 119, 65 2017-02-14, 23, 12, 14	First people 2017-02-19 23:12:10:014	duniot	1.39	33
										10.13.0.2 2017-02-14 23:12:13		dunich	1.38	2
										10.13.0.2 2017-02-14 23.12.09	Codecs PCMA (8)	letaewitch SBC 2	1.30	21
										192,168,110,00 2017-02-14 23:12:08	R factor (8-model) 24.00 MOS average 1.39	Heterwitch SBC 2	1.30	3.
										192.168.119.58 2017-02-14 23.12.07	MOS minimum 1.39	letaswitch SBC 2, Munich	1.38	0.
										192.168.119.57 2017-02-14 23-12-06	Packets Heatwed 130	letaswitch SBC 2	1.39	3.5
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			(Pal		Raula I	Manner	n flows [m]	PCAP	• PDF	192.168.118.52 2017-02-14 23:12:01	Packet loss rate \$0.00 %	Frankturt	1.38	3.
			12.2	· E	1 oave	меззад	e flow +	PLAP	PDP	192.168.119.51 2017-02-14 23:12:00	Job Ta	hankfurt	1.39	31
			15							182, 168, 119, 46 2017-02-14, 23, 12, 55	Atter total 1.00 ms	Hamburg	1.59	3.
										192 168 119 40 2017 02 14 23 11:55		N 10 W 7	1.38	33
										192 168 119 43 2017-02-14 23 11:53	* Message 5ow * PCAP * PDP Help Close	famburg famburg	1.59	39

Detection of One-Way Audio

Filters:	(None)	• Edit A	Advanced	. Save Clear	📢 👳	
DTMF	Call-Transfer	Min	Av	State	State	Audio
				Established		No audio
				Proceeding		One way audio
				Finished		No audio
				Proceeding		One way audio
				Ringing		No audio
				Established		OK
				Ringing		No audio
				Proceeding		One way audio
				Established		OK
				Failed		No audio
				Established		No audio
				Established		ОК
				Redirected	Multi	No audio
				Finished		ОК
				Finished		ОК
						014

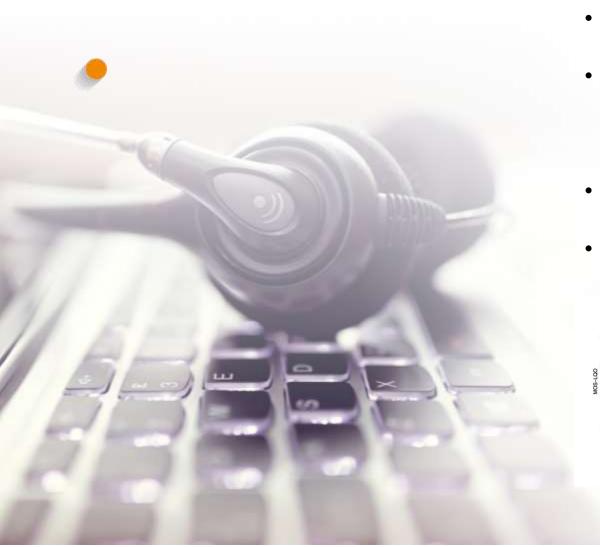
Disadvantage: Realistically solely measures packet loss & jitter Formula for the E-Model

R Factor = Ro - Is - Id - Ie + A

- R Factor: Overall network quality rating (ranges between 0 and 100)
- Ro: Signal to noise ratio
- Is: Impairments simultaneous to voice signal transmission
- Id: Impairments delayed after voice signal transmission
- Ie: Effects of Equipment (e.g. codecs)
- A: Advantage factor (attempts to account for caller expectations)
- In simple terms, the overall quality (R Factor) is calculated by estimating the signal to noise ratio of a
- connection (Ro) and subtracting the network impairments (Is, Id, Ie) that in turn are offset by any
- expectations of quality had by the caller (A).

"Such estimates are only made for transmission planning purposes and not for actual customer opinion prediction (for which there is no agreed-upon model recommended by the ITU-T)."

Perceptual Quality Metrics Latest stnd: ITU-T P.863 POLQA



- Audio plane metrics
- 97% correlation to subjective MOS
 - (within 95% confidence interval)
- Does not include echo or delay which are measured separately with same Test equipment
 - Audio Delay
 - Echo amplitude & time
- DTMF usually measured with same Test equipment
 - Level, frequency & twist
- P.563
 - Non-referenced or single ended measurement
 - Not been successful, Nor widely adopted

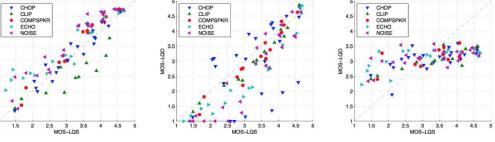


Figure 2: Scattter plots for POLQA, ViSQOL and P.563

POLQA; VISQOL & P.563

Dublin Institute of Technology, & Google Inc. 2015

Comparison: POLQA; ViSQOL & P.563 Dublin Institute of Technology, & Google Inc. 2015

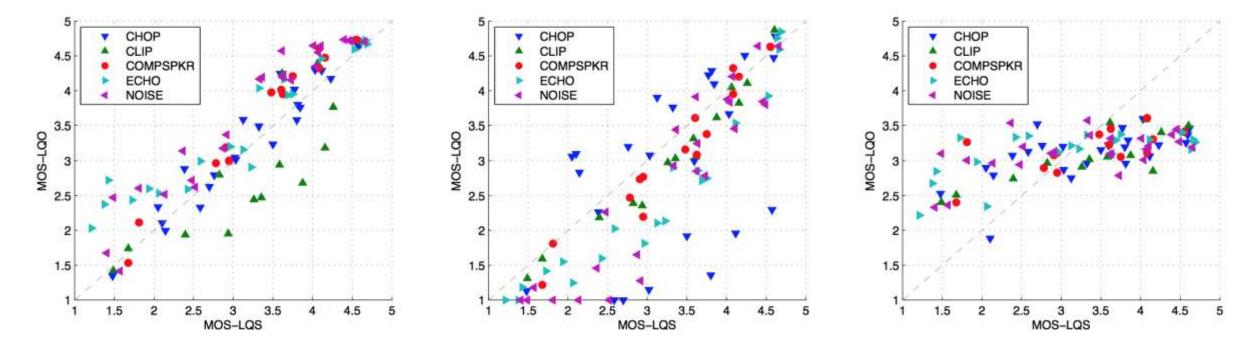
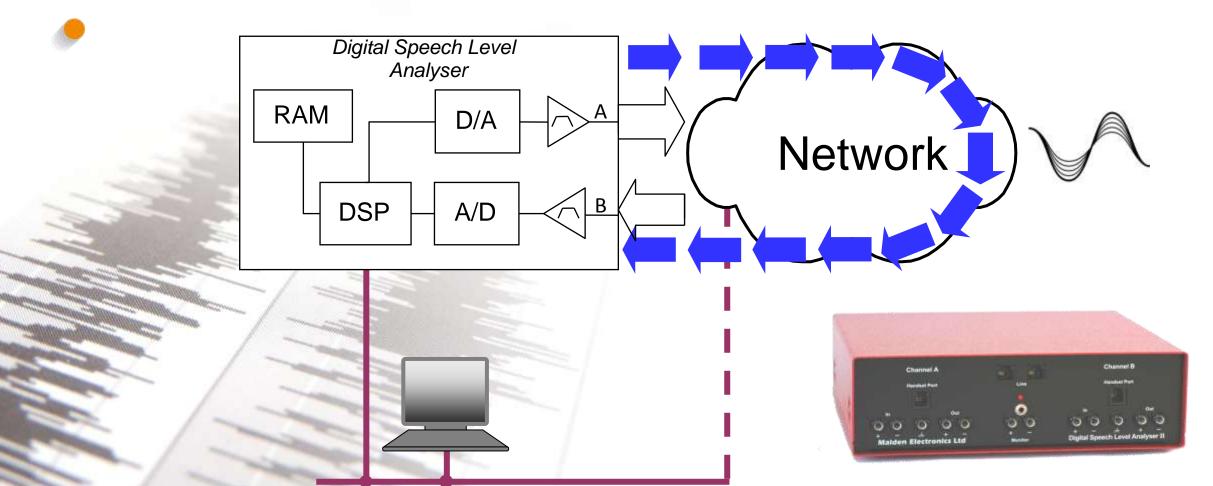


Figure 2: Scattter plots for POLQA, ViSQOL and P.563

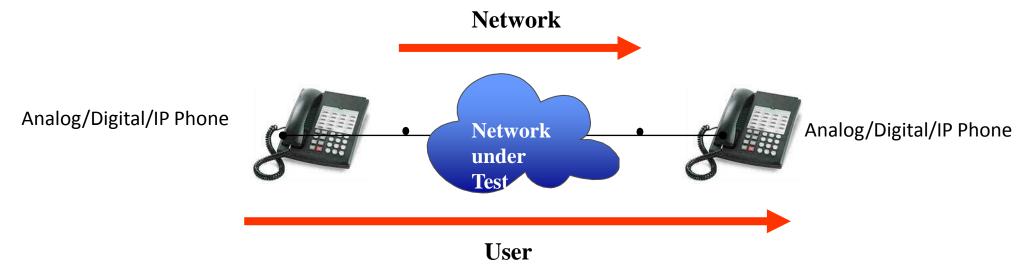
Measuring MOS at "Audio" layer via Analog Interfaces



Measurement Concept

2 measurement points

• Network (analog or digital measurement Endpoint)



The phone can bring distortion (noise, AEC, AGC, ..) to final speech signal

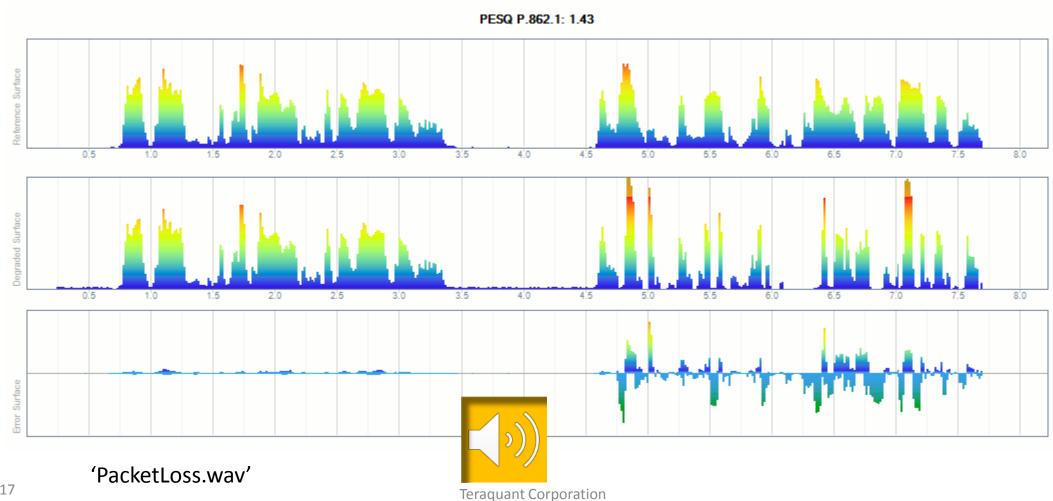
Voice Quality: Root Cause Categories

- 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

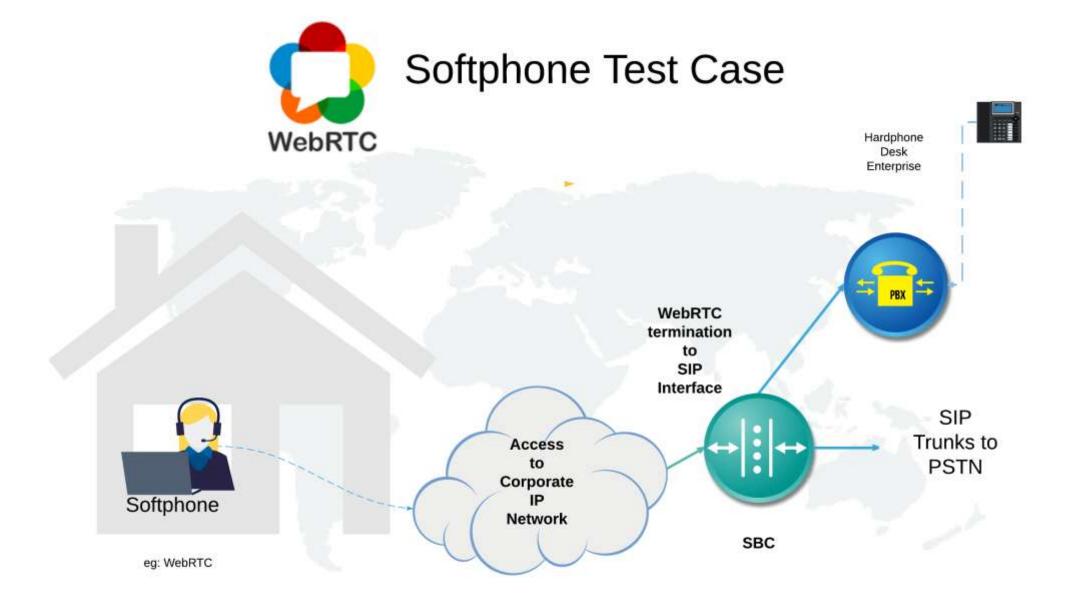




Audio Exhibits Packet Loss



12/4/2017



softphone Starved of CPU

Female 1 – encoded starvation

Female 1 - Decoded starvation

Male 1 - Decoded starvation

Male 1 - encoded starvation









G.726 Packing Order Mismatch

G.726 Bigend to Bigendian



G.726_Bigendian to Littleendian



There are two ways to pack the G.726 code words into the RTP payload bytes: Little endian and big endian. RFC#3551, section 4.5.4 mandates that the SIP SDP must say "G726-32" for little-endian or ""AAL2-G726-32" for big-endian. A VoIP gateway incorrectly signaled "G726-32" but sent big-endian.

G.729A to B Mismatch

Female 1 - Degraded

Male 1 - Degraded





a G.729A codec attempt to decode a G.729B codec. The G.729 decoder does not know how to handle the VAD frames so it adds the data to the data path for the decoder which gets the frame boundaries mixed up (the VAD frames are much smaller than the speech frames) resulting in what we are seeing.

Codec Mismatch

G.729B Decoded by a Codec not Supporting Silence Suppression



Low volume speech clip

G.729 Codec is Impaired by Background Music



The file G.729_prompt_over_music.wav shows the effect of music on G.729. For much of the time, the music is not even recognizable behind the speech. Instead, the speech is distorted and the background sounds like noise. Occasionally (starting at around 12 seconds) fragments of music are detectable.

Loss of Synchronization with ISDN PRI

• Listen to crackle at the clockslip. The clicks are mostly at intervals of 20 msec.





Try POLQA for Free Submit speech files to Teraquant

- Capture *Reference* from input and degraded leg On Palladion
 - Caution Good leg/*Reference* might be degraded
 - Click <u>http://www.teraquant.com/Try_POLQA_for_Free</u>
 - Submit Reference & Degraded file
- Download <u>Reference</u> speech file from Teraquant
- Download 2 x active measurement Endpoints

