

# 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)




Web: [www.teraquant.com](http://www.teraquant.com)

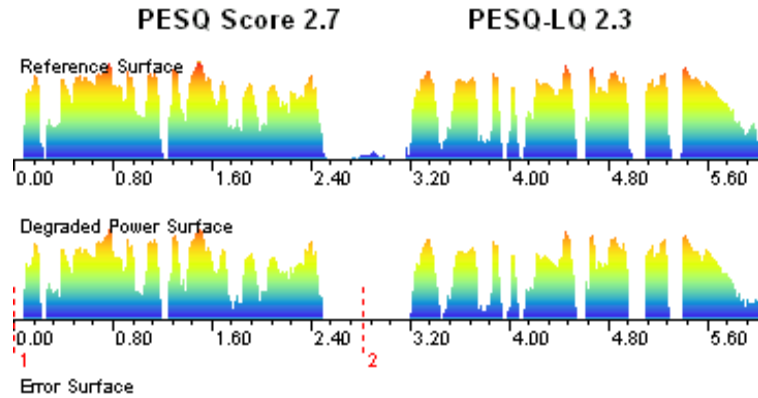
**ORACLE** | *acme packet*

Oracle Gold Partner & OEM

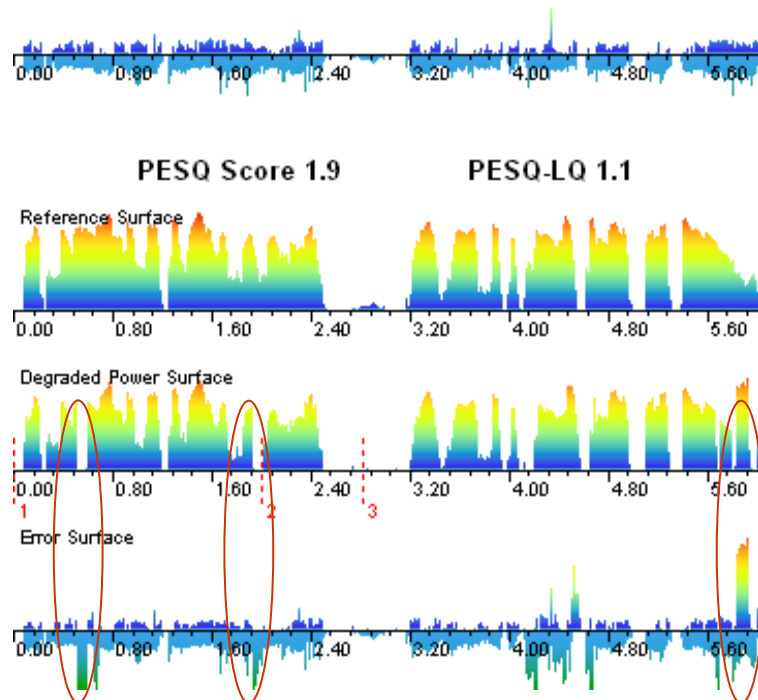
# Agenda

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- ▶ 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



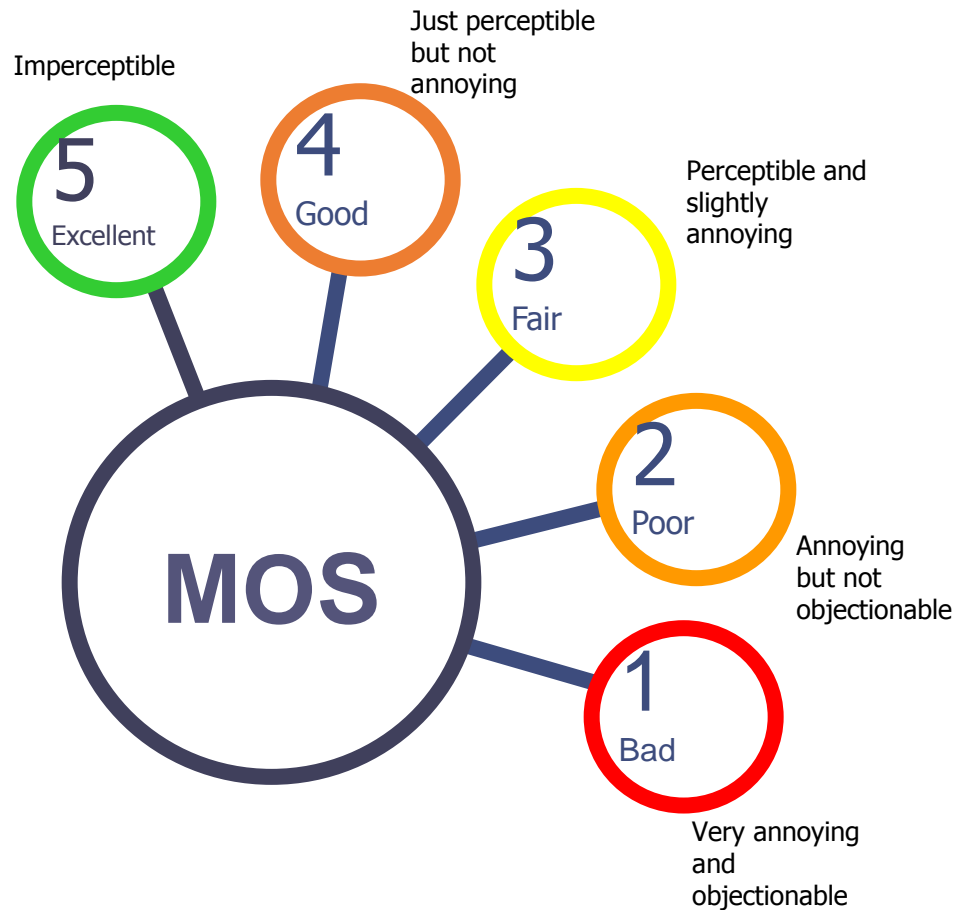
LAN with no load.  
Speech quality  
moderate



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



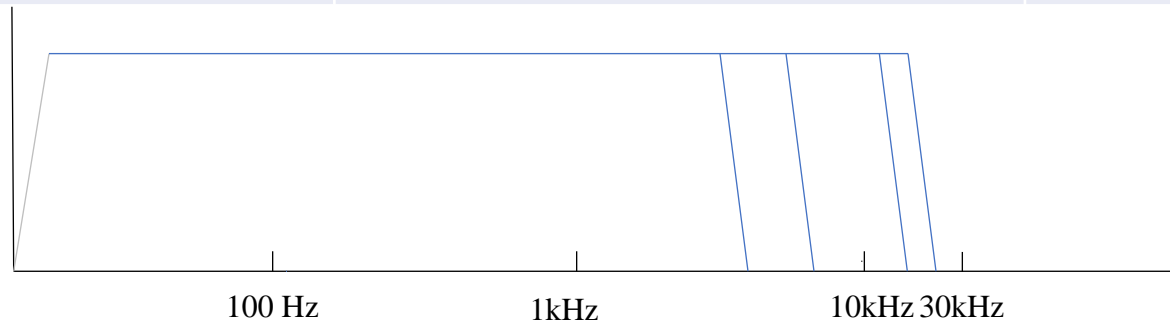
# MOS - Leading Indicator of Call Quality



- 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

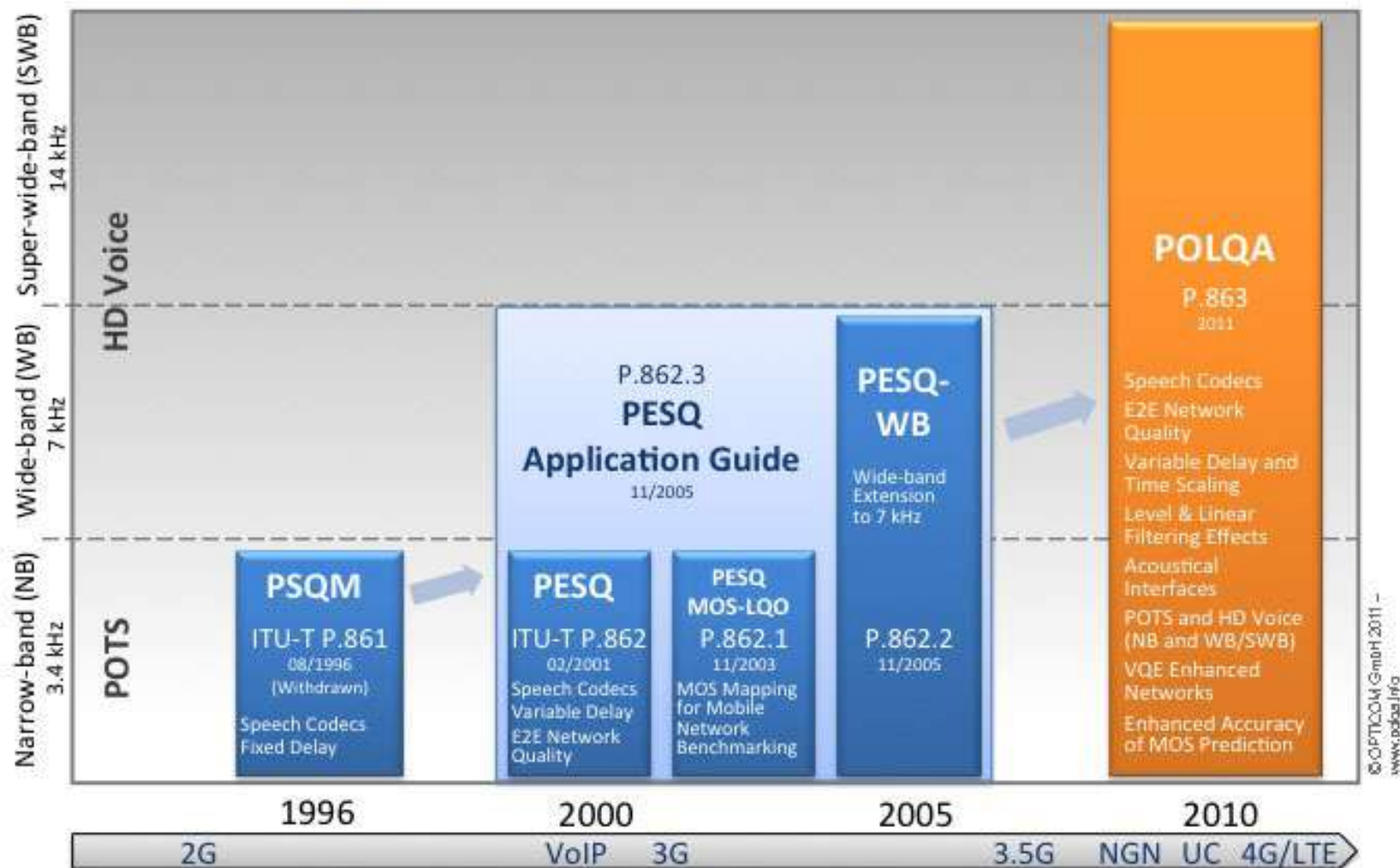
# Types of Objective Measurements

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





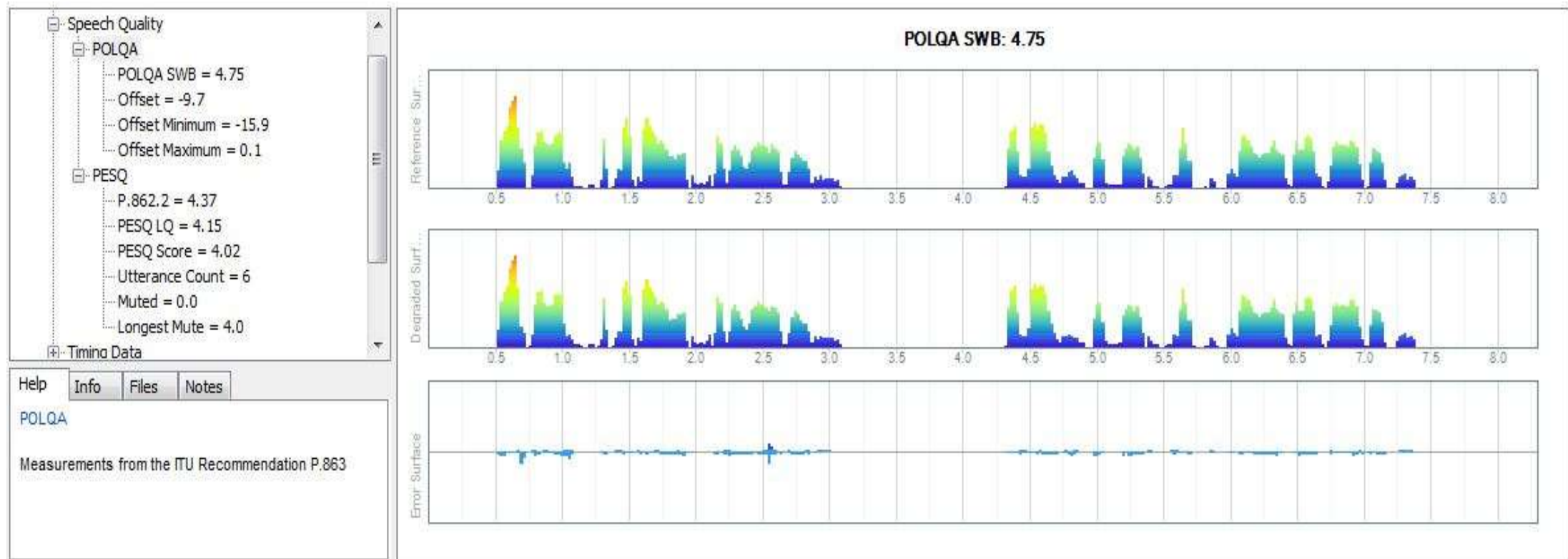
## Evolution of ITU-T Recommendations for Voice Quality Testing (P.86x - Full Reference MOS-LQO)



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www.polqa.info

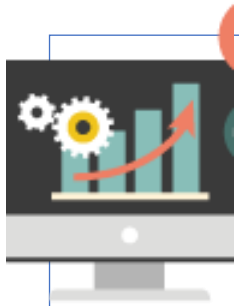
# POLQA Solutions

## Time Warping

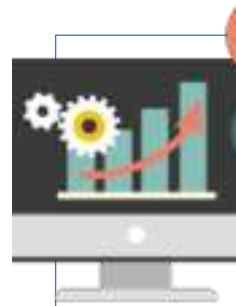




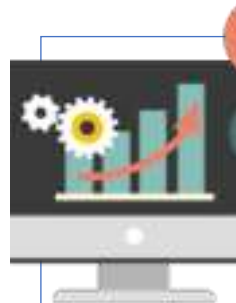
# Agenda



MOS Subjective v Objective



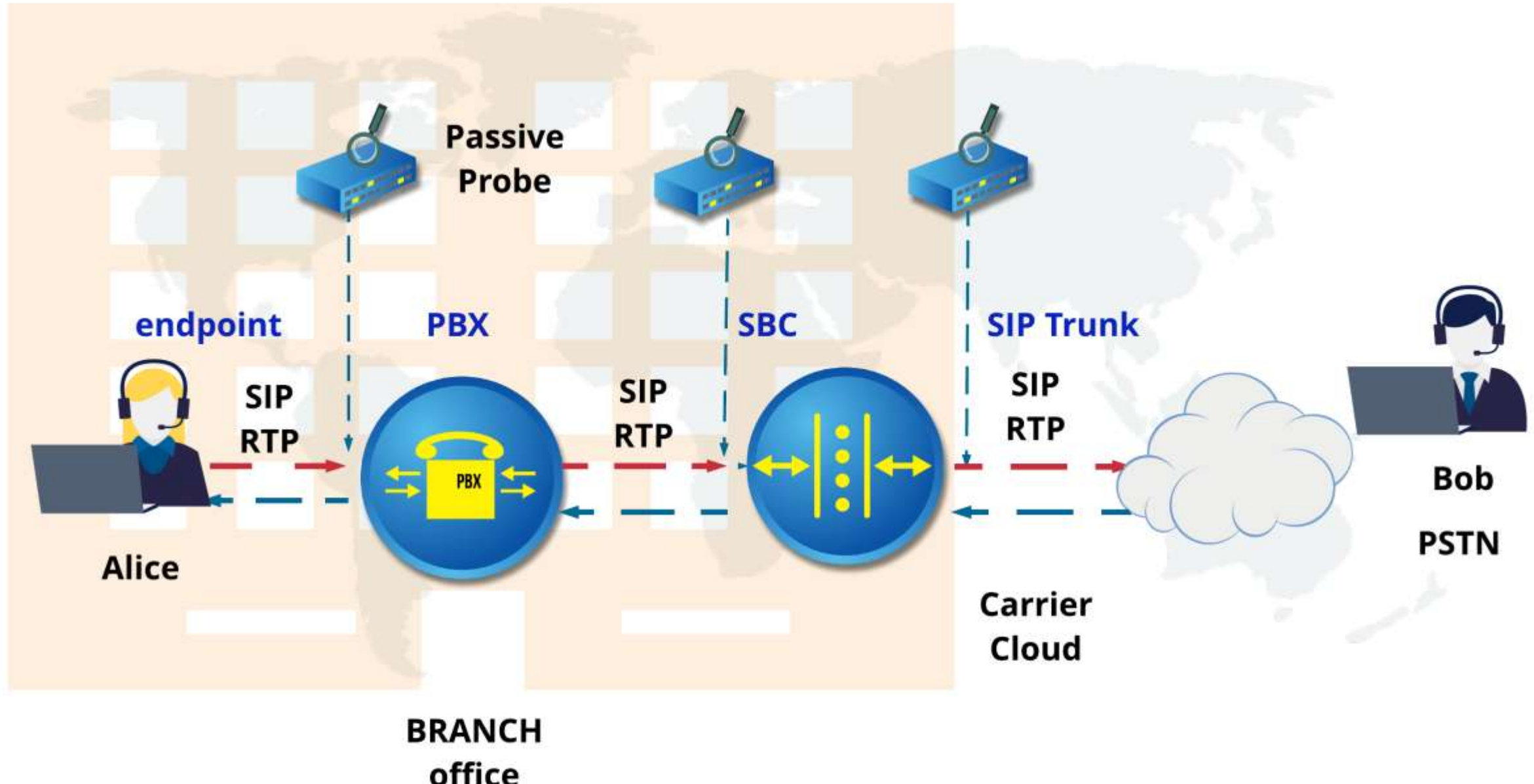
Troubleshooting at Audio layer v Packet Transport layer



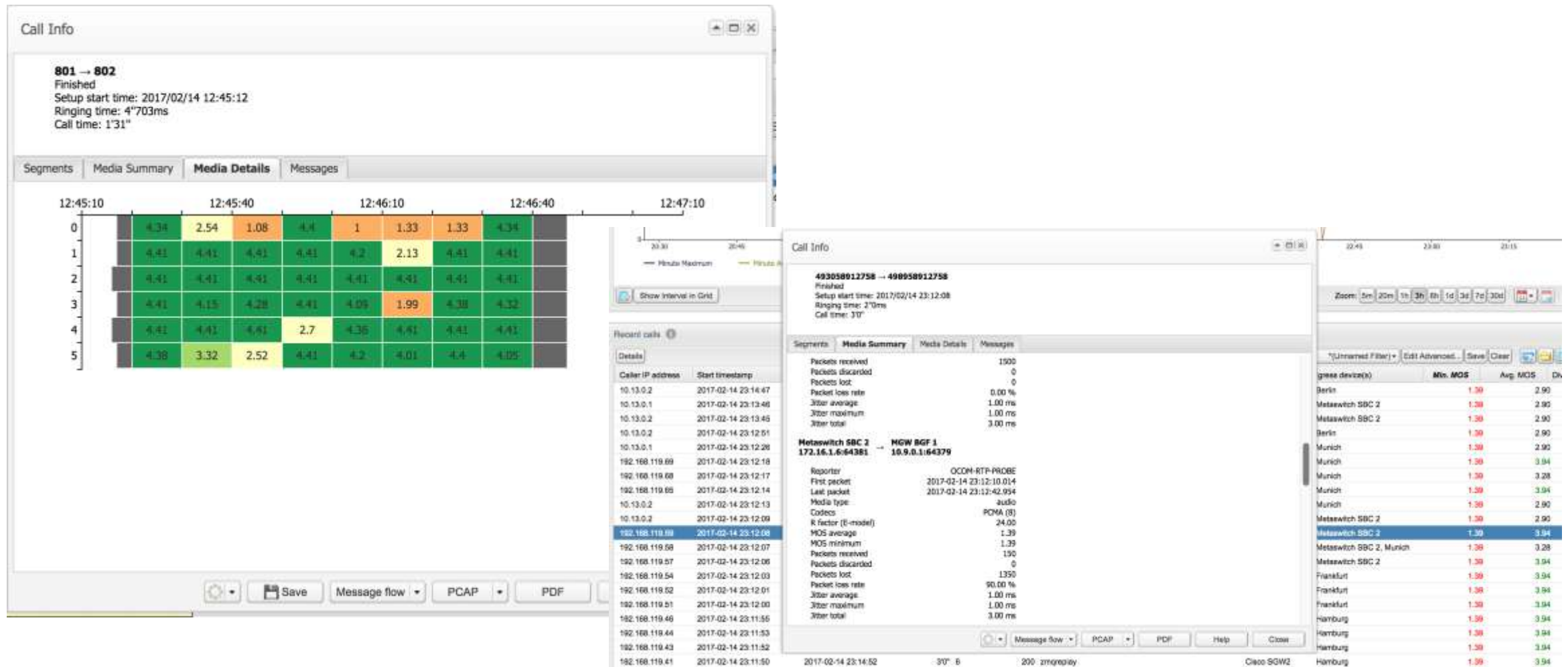
Impairments v Root Cause

# 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

Filters: (None) Edit 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
s				Established		OK
				Failed		No audio
				Established		No audio
				Established		OK
				Redirected	Multi...	No audio
				Finished		OK
				Finished		OK
				Finished		OK

# Disadvantage: Realistically solely measures packet loss & jitter

## Formula for the E-Model

$$R \text{ Factor} = R_o - I_s - I_d - I_e + A$$

- R Factor: Overall network quality rating (ranges between 0 and 100)
- $R_o$ : Signal to noise ratio
- $I_s$ : Impairments simultaneous to voice signal transmission
- $I_d$ : Impairments delayed after voice signal transmission
- $I_e$ : 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 ( $R_o$ ) and subtracting the network impairments ( $I_s$ ,  $I_d$ ,  $I_e$ ) 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

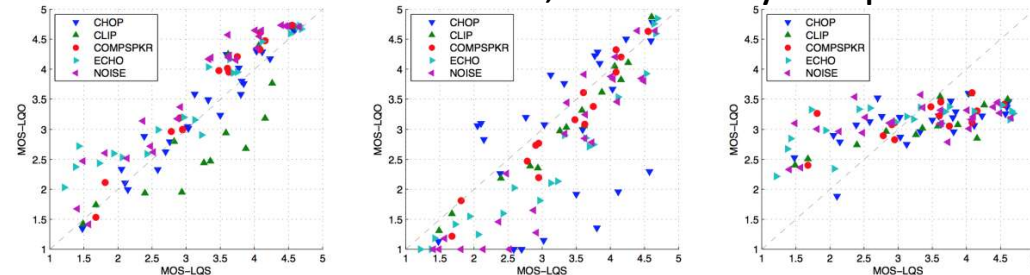


Figure 2: Scatter plots for POLQA, ViSQOL and P.563

POLQA; ViSQOL & P.563

Dublin Institute of Technology, & Google Inc. 2015



# Comparison: POLQA; ViSQOL & P.563

## Dublin Institute of Technology, & Google Inc. 2015

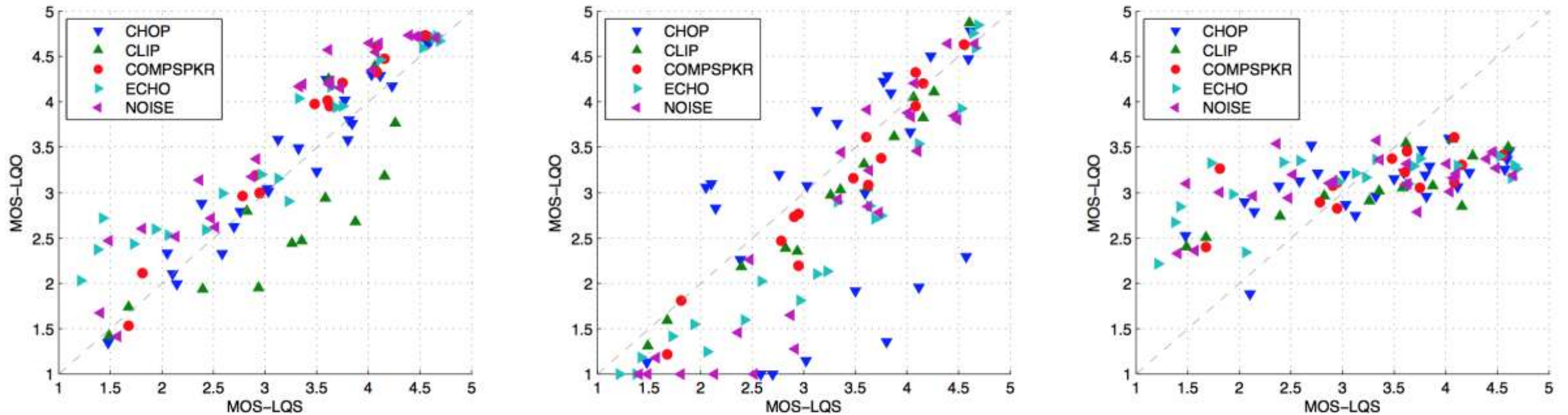
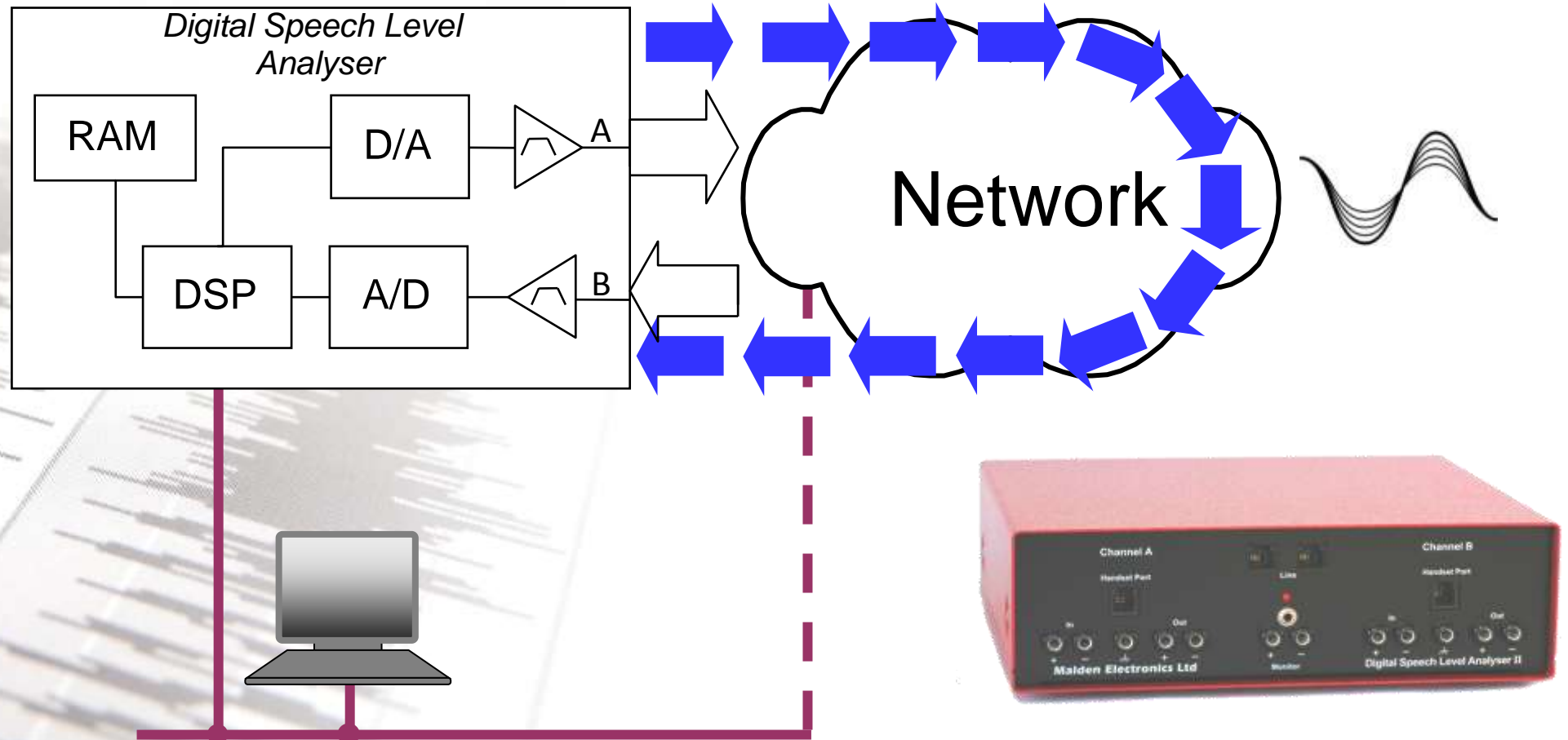


Figure 2: Scatter plots for POLQA, ViSQOL and P.563

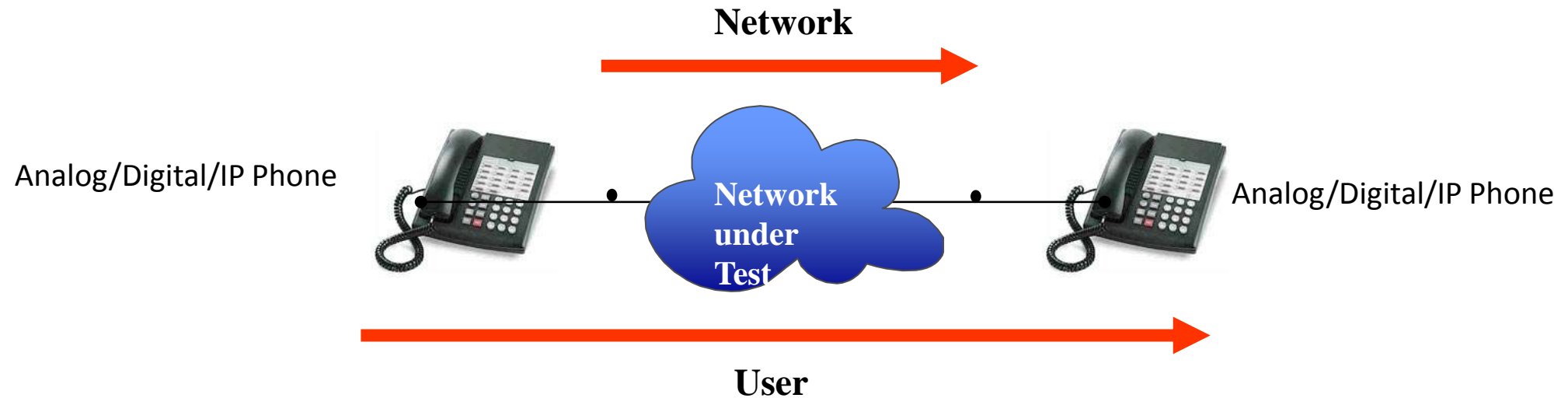
# Measuring MOS at “Audio” layer via Analog Interfaces



# Measurement Concept

## 2 measurement points

- Network ( analog or digital measurement Endpoint)



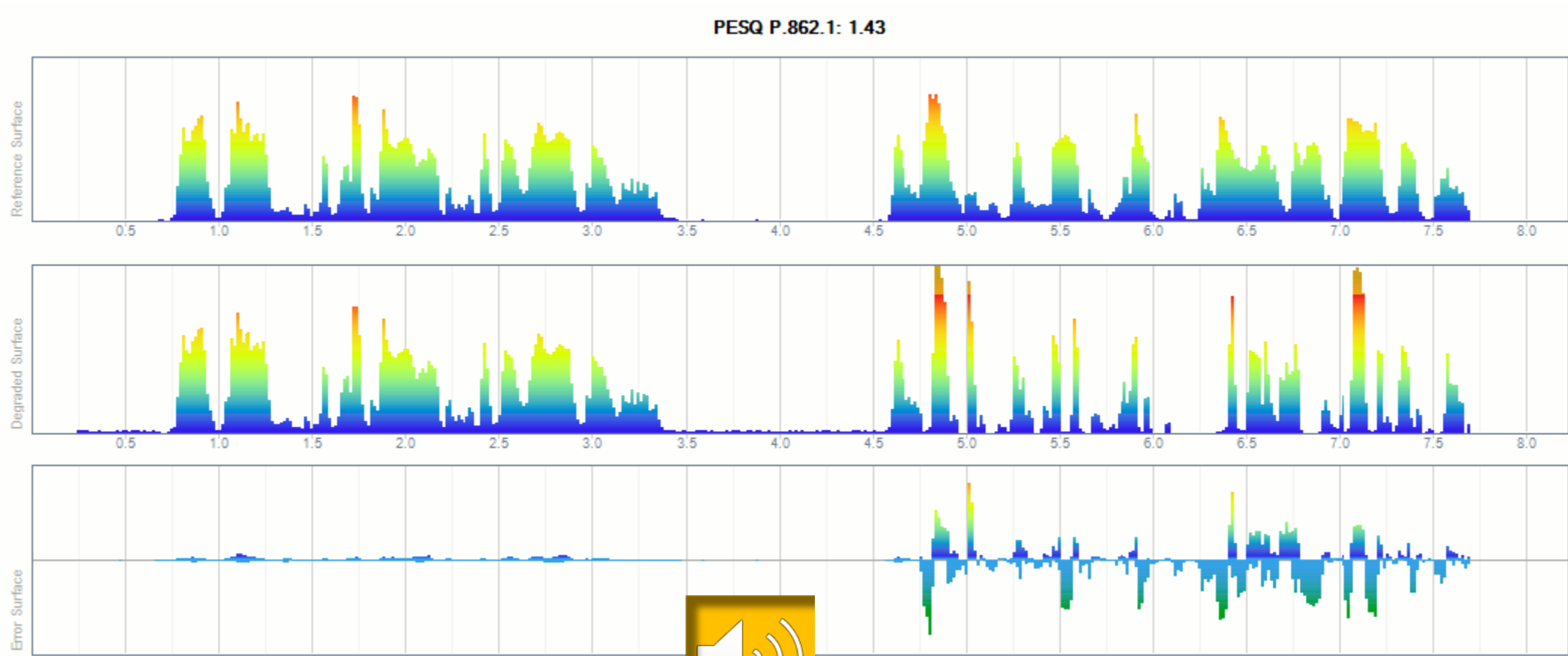
The phone can bring distortion (noise, AEC, AGC, ..) to final speech signal

# 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

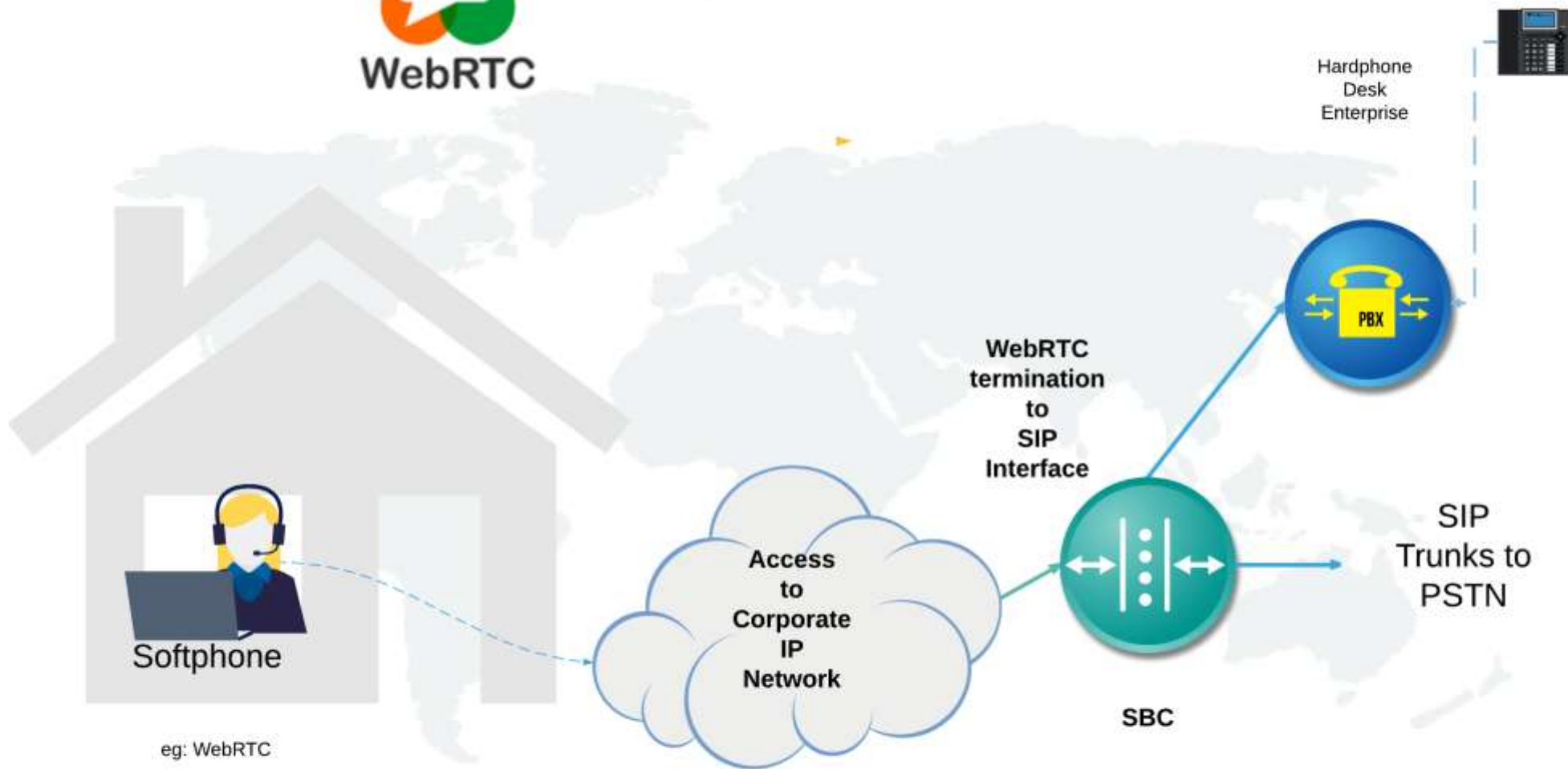


'PacketLoss.wav'





# Softphone Test Case





# softphone Starved of CPU

Female 1 – encoded starvation



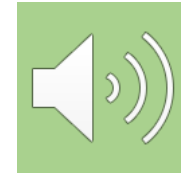
Female 1 - Decoded starvation



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 [http://www.teraquant.com/Try POLQA for Free](http://www.teraquant.com/Try_POLQA_for_Free)
  - Submit Reference & Degraded file
- Download **Reference** speech file from Teraquant
- Download 2 x active measurement Endpoints

