



International Telecommunication Union

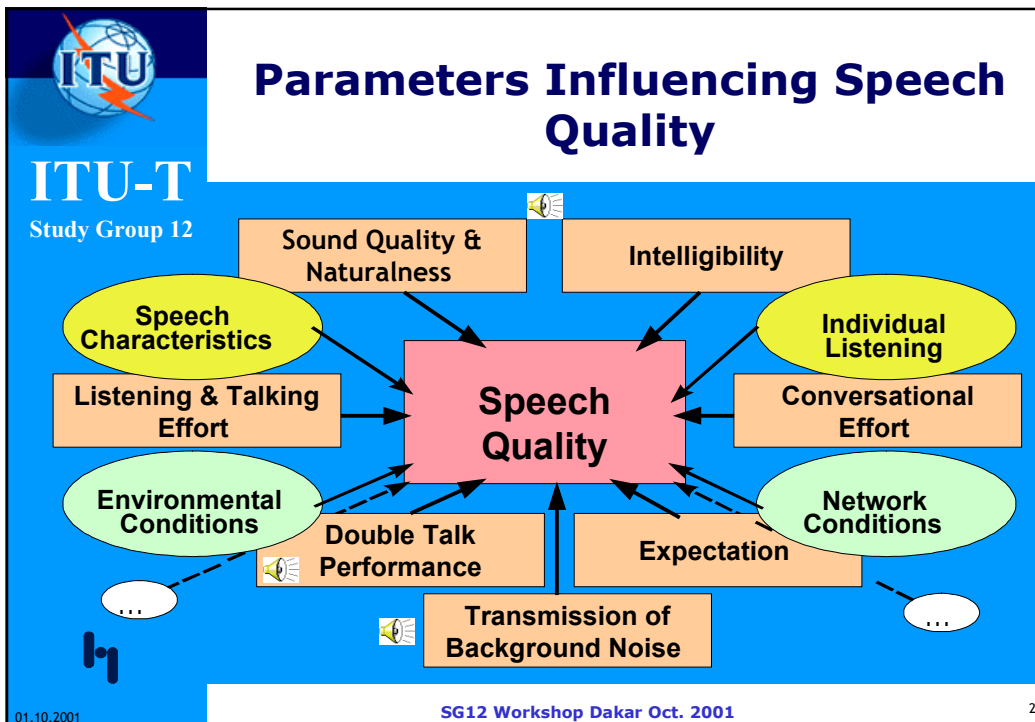
# ITU-T Study Group 12

## Speech Communication from Mouth to Ear: Voice Quality Aspects in Modern Telecommunication Networks

Dr.-Ing. H. W. Gierlich

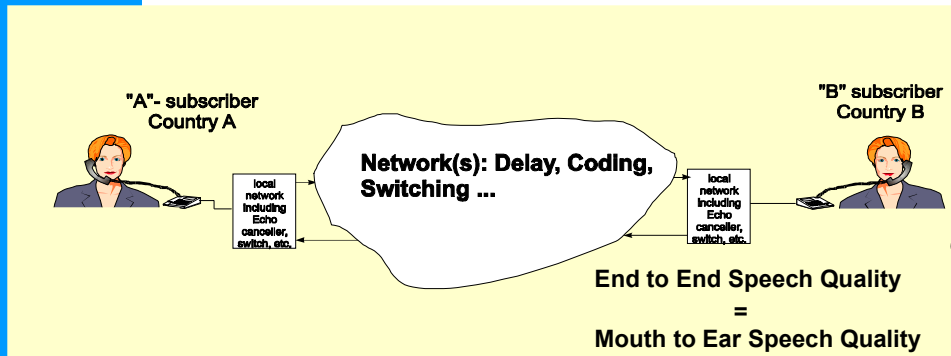


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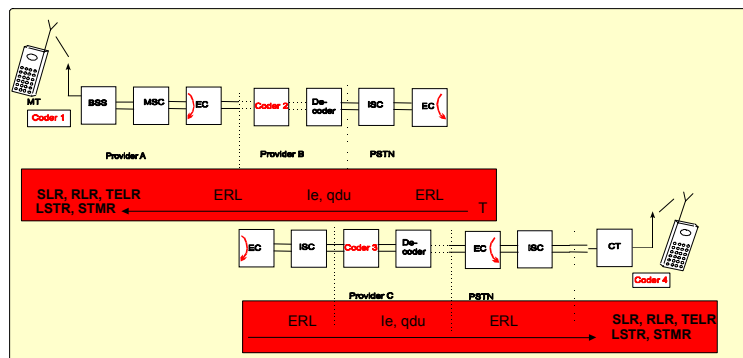




## The Telephone Conversation:



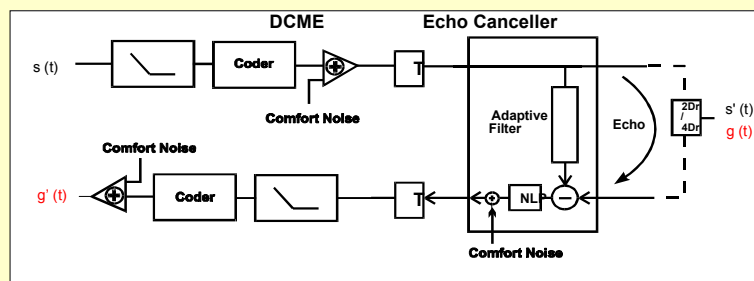
## Network Configuration and Transmission Parameter



- BSS - Base Station System
- MSC - Mobile Switching Center
- EC - Echo Canceller
- ISC - International Switching Center
- PSTN - Public Switched Telephone Network
- CT - Cordless Telephone
- MT - Mobile Telephone

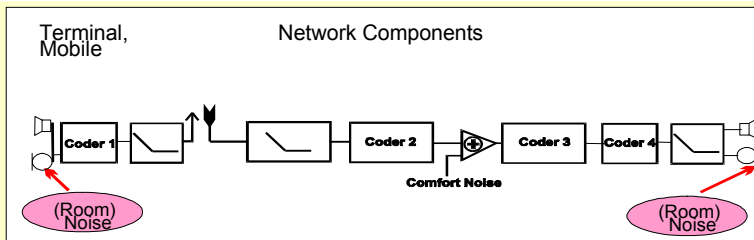


## Interaction Example: DCME and Echo Celler



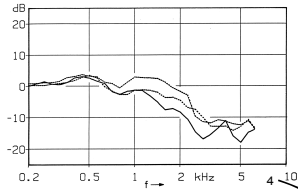
- Cascaded comfort noise
- Cascaded switching
- Double talk detection

## Interaction Example Terminal/Network

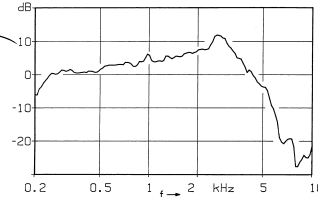
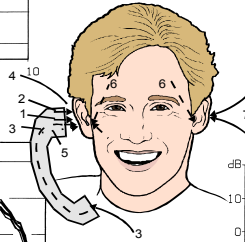
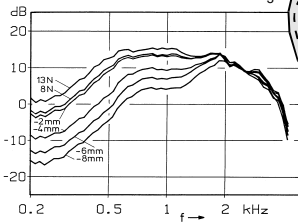


- Noise and addition of comfort noise
- Cascaded switching
- Speech detection and noise
- Cascaded speech coding & various types of noise

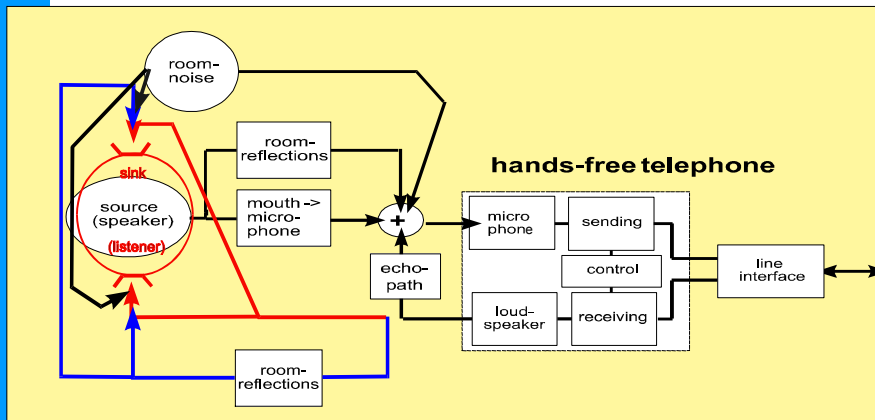
## Signal and Noise Transmission in Handset Telephony




- 1 Signal (Voice)
- 2 Noise, Transmission Noise and Room Noise
- 3 Noise, Sidetone Coupling
- 4 Noise, Acoustical Sidetone
- 5 Noise, Structure Borne
- 6 Noise, Bone Conduction
- 7 Noise, Coupled to Ear not Covered by the Handset




## The Hands-Free Situation





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## Parameters Influencing Speech Quality During:

Conversation	Talking	Listening
<p><b>linear distortions</b></p> <ul style="list-style-type: none"> <li>• transfer functions</li> <li>• attenuation</li> <li>• delay</li> <li>• reverberance ....</li> </ul> <p><b>non linear distortions</b></p> <ul style="list-style-type: none"> <li>• (in) harmonic distortions</li> <li>• clipping</li> <li>• coding ...</li> </ul> <p><b>additive noise components</b></p> <ul style="list-style-type: none"> <li>• system noise</li> <li>• background noise</li> <li>• echo</li> <li>• double talk ...</li> </ul> <p style="color: red;">during single- and double talk</p>	<p><b>linear distortions</b></p> <ul style="list-style-type: none"> <li>• echo</li> <li>• reverberancel</li> <li>• delay ...</li> </ul> <p><b>non linear distortions</b></p> <ul style="list-style-type: none"> <li>• (in)harmonic distortions</li> <li>• clipping</li> <li>• coding ... (of the echo signal)</li> </ul> <p><b>additive noise components</b></p> <ul style="list-style-type: none"> <li>• system noise</li> <li>• background noise</li> <li>• channel noise...</li> </ul> <p>(during talking)</p>	<p><b>linear distortions</b></p> <ul style="list-style-type: none"> <li>• transfer functions</li> <li>• attenuation</li> <li>• reverberancel ....</li> </ul> <p><b>non linear distortions</b></p> <ul style="list-style-type: none"> <li>• (in)harmonic distortions</li> <li>• clipping</li> <li>• coding ...</li> </ul> <p><b>additive noise components</b></p> <ul style="list-style-type: none"> <li>• system noise</li> <li>• background noise</li> <li>• channel noise...</li> </ul>


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## Instrumental Measures for:

Intelligibility    Speech quality    Quality during conversation

measurements during single talk:

- frequency responses
- loudness ratings
- switching characteristics
- distortion measurements
- measurements of S/N or N

measurement signals: artificial, eventually speech like

Measurements during single- and double-talk:

- delay
- echo-loss
- switching characteristics
- frequency responses
- loudness ratings
- variation of background noise

measurement signals: speech or speech-like

measurement during single talk psychoacoust. motivated measures:

P.862 (PESQ)  
TOSQA  
PACE  
PAMS ...

measurement signals: speech or speech-like

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tr\_505



## Instrumental Measures

### "Traditional" Instrumental Measures

#### Single Talk Situation:

- Transfer function
- Loudness Ratings
- Distortion
- System-dynamic
- System-linearity
- Sensitivity against room noise
- Background noise transm.
- Switching characteristics

#### Double Talk Situation:

- Transfer function during double talk
- Loudness Ratings
- Distortion
- System-dynamic
- System-linearity
- Sensitivity against room noise
- Background noise transmission
- Switching and echo characteristics

- Measurement applied to complete end to end configuration
- Terminals must be included
- Noise conditions (at the subscriber) need to be included

"Listen and Analyze"



## The Most Important Parameters for LTI-Terminals (e.g. Handset Terminals)

- Frequency response in sending & SLR
- Frequency response in receiving & RLR
- Background noise sensitivity in sending ( SM)
- Background noise sensitivity in receiving (LSTR)
- Echo performance (TCL, ERLt)



## Performance Limits:

- Echo: G.131(single talk and double talk)
- G.168 (echo canceller)
- Loudness Ratings: P.79
- Switching characteristics: P.340
- E-model: G.107, G.108, G.108.1, G.113



## Typical Single Values

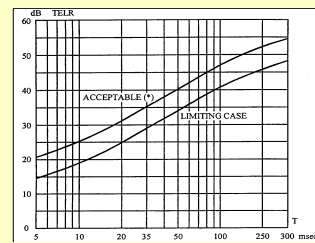
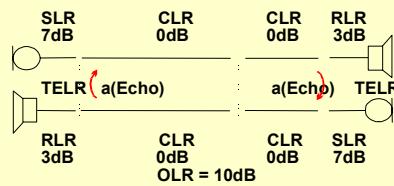


Fig. 1 G.131

### planning values:

- loudness ratings
- Impairment factors  $le$
- delay -> echo cancellation/suppression

### problems:

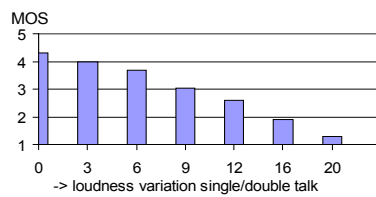
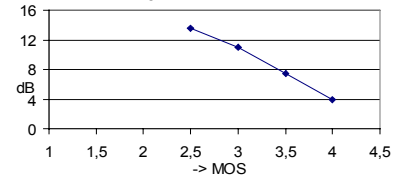
- values frequency dependant
- non linear, time variant transmission properties
- proper consideration of codecs, cascading of codecs, echo cancellers..
- interaction of different transmission systems (e.g. PSTN, IP...)



## Double Talk Requirements

echo during double talk:  
the effect of echo level  
increase during double  
talk on subjects judgement

Echo level offset single talk/double talk



level variation between  
single- and double talk:  
the effect on subjects  
judgement



## Conclusions

- Typical network conditions and user conditions have to be taken into account
- Overall quality description not complete yet for non LTI-systems
- Various quality parameters for single and double talk situations available in ITU