The Good, the Bad and the Muffled: the Impact of Different Degradations on Internet Speech

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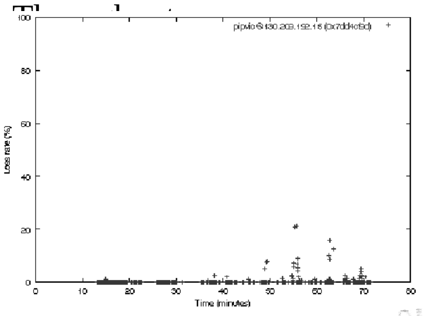
Introduction

- Multimedia conference is a growing area
- Well-known that need good quality audio for conferencing to be successful
- Much research focused on improving delay, jitter, loss
- Many think bandwidth will fix
  - But bandwidth has been increasing exponentially while quality not!

Motivation

- Large field trial from 1998-1999
  - 13 UK institutions
  - 150 participants
- Recorded user Perceptual Quality
  - Beginning, Middle, End
  - *(Why not only at end?)*
  - *(Why not continuously?)*
- Matched with objective network performance metrics
- Suggested that network was not primary influence on PQ!

Example: Missing Words



- 1 hour Meeting
- UCL to Glasgow
-Super Janet
-RTP reports 2-5 secs

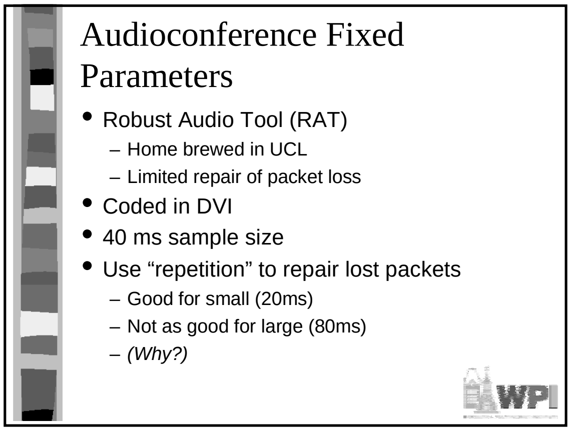
- But loss usually far less than 5%!

Problems Cited

- Missing words
  - Likely causes: packet loss, poor speech detection, machine glitches
- Variation in volume
  - Likely causes: insufficient volume settings (mixer), poor headset quality
- Variation in quality among participants
  - Likely causes: high background noise, open microphone, poor headset quality
- *Experiments* to measure which affect quality

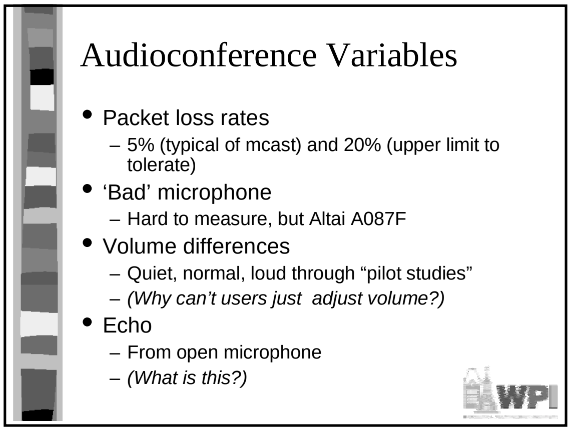
Outline

- Introduction
- ***Experiments***
- Results
- Conclusions



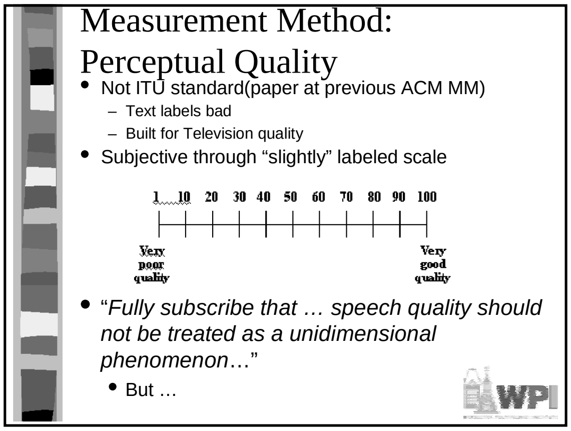
Audioconference Fixed Parameters

- Robust Audio Tool (RAT)
  - – Home brewed in UCL
  - – Limited repair of packet loss
- Coded in DVI
- 40 ms sample size
- Use “repetition” to repair lost packets
  - – Good for small (20ms)
  - – Not as good for large (80ms)
  - – *(Why?)*



Audioconference Variables

- Packet loss rates
  - – 5% (typical of mcast) and 20% (upper limit to tolerate)
- ‘Bad’ microphone
  - – Hard to measure, but Altai A087F
- Volume differences
  - – Quiet, normal, loud through “pilot studies”
  - – *(Why can’t users just adjust volume?)*
- Echo
  - – From open microphone
  - – *(What is this?)*

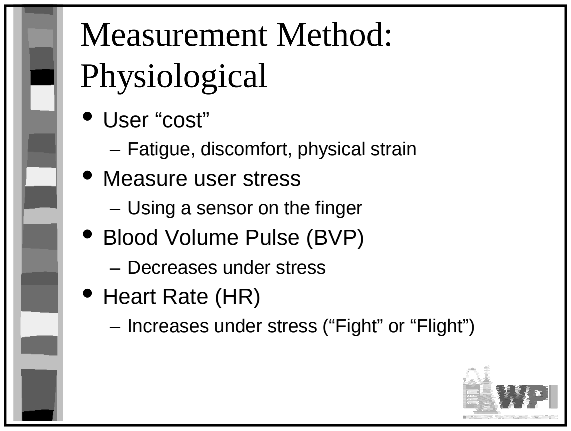


Measurement Method: Perceptual Quality

- Not ITU standard(paper at previous ACM MM)
  - – Text labels bad
  - – Built for Television quality
- Subjective through “slightly” labeled scale

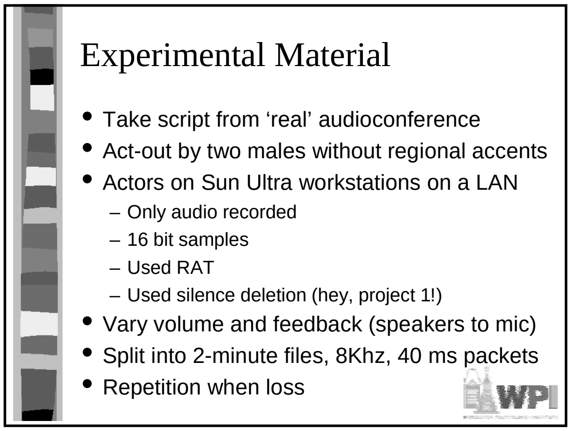
1 10 20 30 40 50 60 70 80 90 100
Very poor quality
Very good quality

- “*Fully subscribe that … speech quality should not be treated as a unidimensional phenomenon…*”
  - But …



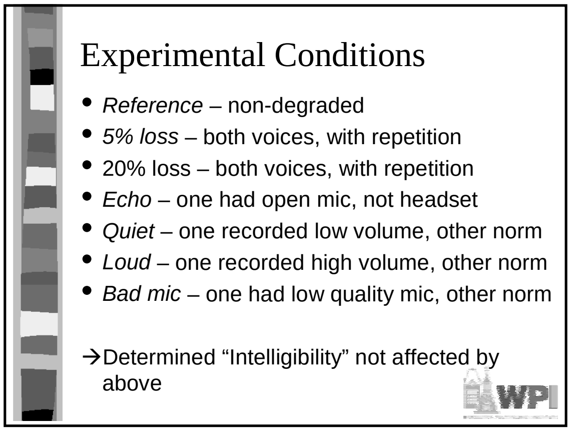
Measurement Method: Physiological

- User “cost”
  - – Fatigue, discomfort, physical strain
- Measure user stress
  - – Using a sensor on the finger
- Blood Volume Pulse (BVP)
  - – Decreases under stress
- Heart Rate (HR)
  - – Increases under stress (“Fight” or “Flight”)



Experimental Material

- Take script from ‘real’ audioconference
- Act-out by two males without regional accents
- Actors on Sun Ultra workstations on a LAN
  - – Only audio recorded
  - – 16 bit samples
  - – Used RAT
  - – Used silence deletion (hey, project 1!)
- Vary volume and feedback (speakers to mic)
- Split into 2-minute files, 8Khz, 40 ms packets
- Repetition when loss



Experimental Conditions

- *Reference* – non-degraded
- *5% loss* – both voices, with repetition
- 20% loss – both voices, with repetition
- *Echo* – one had open mic, not headset
- *Quiet* – one recorded low volume, other norm
- *Loud* – one recorded high volume, other norm
- *Bad mic* – one had low quality mic, other norm

→Determined “Intelligibility” not affected by above

Subjects

- 24 subjects
  - – 12 men
  - – 12 women
- All had good hearing
- Age 18 – 28
- None had previous experience in Internet audio or videoconferencing

Procedure

- Each listened to seven 2-minute test files twice
  - – Played with audio tool
- First file had no degradations ("Perfect")
  - – Users adjusted volume
  - – Were told it was "best"
- Randomized order of files
  - – Except "perfect" was 1st and 8th
  - – So, 7 conditions heard once than another order
- Baseline physiological readings for 15 min
- When done, use 1-100 slider and explain rating (tape-recorded)

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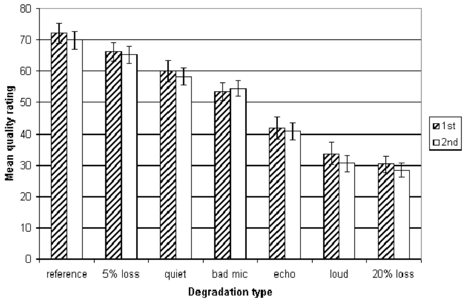
Quality Under Degradation

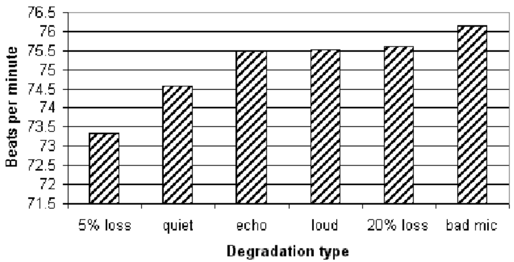


- Statistically significant?

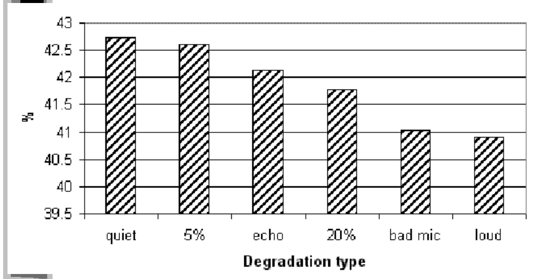
Statistical Significance Tests

- Anova Test
  - – For comparing means of two groups: first hearing and second hearing
  - – No statistical difference between the two groups
- Analysis of variance
  - – Degradation effect significant
    - + *Reference* and all others are different
  - – *Reference* and *5% loss* the same
  - – *Reference* and *Quiet* the same
  - – *5% Loss* and *Quiet* the same
  - – *20% Loss* and *Echo* and *Loud* the same

Physiological Results: HR



Physiological Results: BVP



•Statistically significant?

Physiological Statistical Significance Tests

- *Bad mic*, *loud* and *20% loss* all significantly more stressful than *quiet* and *5% loss*
- *Echo* significantly more stressful than *quiet* in the HR data only
- Contrast to quality!
  - *Bad Mic* worse than *20% loss*
  - Least stressful were *quiet* and *5% loss*

Qualitative Results

- Asked subjects to describe why each rating
- Could clearly identify
  - *quiet*, *loud* and *echo*
- *Bad mic*
  - 'distant', 'far away' or 'muffled'
  - 'on the telephone', 'walkie-talkie' or 'in a box'

Qualitative Results of Loss

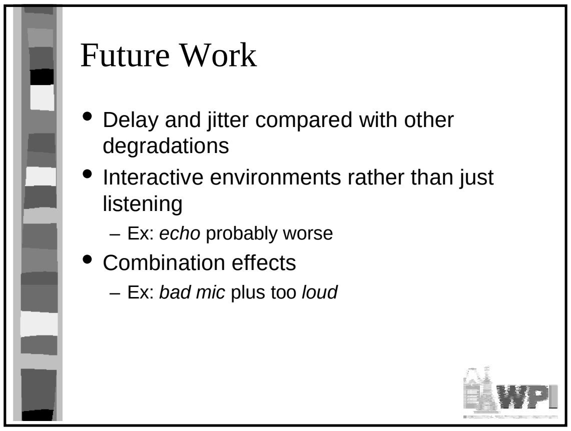
- *5% loss*
  - 'fuzzy' and 'buzzy' (13 of 24 times)
    - From waveform changing in the missing packet and not being in the repeated packet
  - 'robotic', 'metallic', 'electronic' (7 times)
- *20% loss*
  - 'robotic', 'metallic', 'digital', 'electronic' (15 times)
  - 'broken up' and 'cutting out' (10 times)
  - 'fuzzy' and 'buzzy' infrequently (2 times)
- 5 said '*echo'*, 10 described major volume changes
  - Not reliably see the cause of the degradation

Discussion

- *5% loss* is different than *reference* condition (despite stats) because of descriptions
  - But subjects cannot identify it well
  - Need a tool to identify impairments
- *20% loss* is worse than *bad mic* based on quality, but is the same based on physiological results
  - need to combine physiological and subjective
- Methodology of field trials to design controlled experiments can help understand media quality issues

Conclusion

- Audio quality degradation not primarily from loss
  - Volume, mic and echo are worse
  - And these are *easy* to fix! Educating users harder.
- By getting descriptions, should be easier to allow users to diagnose problems
  - Ex: 'fuzzy' or 'buzzy' to repetition for repair
- Volume changes harder
  - Could be reflected back to the user
  - Could do expert system to make sure certain quality before being allowed in



Future Work

- Delay and jitter compared with other degradations
- Interactive environments rather than just listening
  - Ex: *echo* probably worse
- Combination effects
  - Ex: *bad mic* plus too *loud*