Mobile Systems

Lab_Supp_3: Bit-error control

COMP28512

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Task 3

3.1: Effect on speech quality of reducing transmit power
3.2: Apply (3,1) repetition scheme as FEC method
3.3: Apply ARQ to text with CRC
3.4: Apply convolutional FEC coding to speech
3.5 Conv coding with ARQ applied to text

Task 3.1: Talk time & energy per bit

- Assume mobile phone is using 1 Watt of power to send speech at 128 kbit/s.
- If battery holds 18000 Joules, how much talk time?
- Ans: 18000 Joules at 1 Joule/s (Watt) gives:
  18000 s = 5 hours
- What is the average energy per bit at the transmitter?
- Ans: 1 Joule/s ÷ 128×10^3 bit/s = $(1/128)\times10^{-3}$ Joules per bit
- Assuming 50 dB loss over channel to receiver, what is average energy per bit (Eb) at the receiver?
- Ans: $(1/128)\times10^{-3} \div 10^5 = (1/128)\times10^{-8}$ Joules per bit

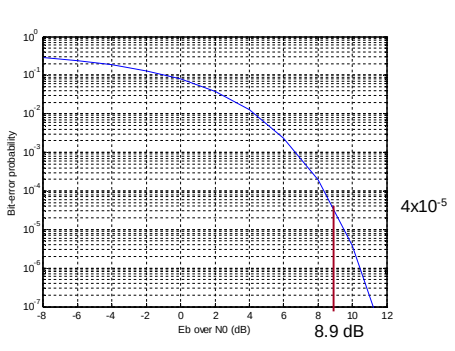
Noise at receiver

- Radio channel has a certain bandwidth, say 30,000 Hz.
- Affected by noise at the receiver,
- It is common to measure this noise in Watts per Hz.
- This is 'power spectral density' N0
- Typical value: $N0 = 10\times10^{-12}$.

Eb/N0

- What is Eb/N0 in dB at the receiver?
- Ans: $10\times\log_{10}((1/128)\times10^{-8} / (10\times10^{-12}))$
  $= 10\log_{10}(7.8)$
  $= 8.93$ dB.
- Assume bits are transmitted by "binary minimum shift keying" (binary msk) as used by 2G mobile phones.
- Form of frequency modulation:
  - a certain freq for '1' & a different freq for '0'
- Well known formula gives expected bit-error probability:
  $beP = 0.5*erfc(\sqrt{(Eb/N0)})$
- Next slide plots this formula, & allows you to deduce that:
  $beP \approx 4\times10^{-5}$

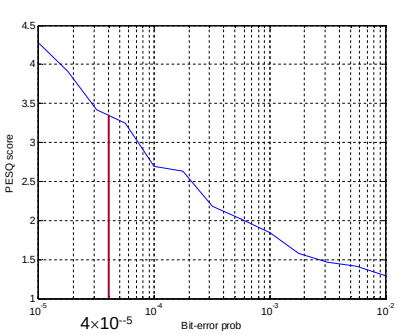
Waterfall graph for msk



PESQ score against beP

- We now know how bit-error probability varies with signal to noise ratio (En/NO).
- Often called 'bit-error rate' (BER) rather than beP.
- Interesting to discover how speech quality varies with BEP (or BER).
- Measure speech quality automatically using PESQ.
- Task 3 produces a demonstration of how speech quality gets worse as BER increases.
- Following graph may be produced by experiment:

PESQ score against beP



Speech quality obtained

- From previous graph, PESQ obtained is about 3.4.
- Assume we try to extend battery life by reducing transmit power from 1 Watt to 0.8 Watt.
- Battery life increases from 5 to 6.25 hrs.
- Eb decreases to $(1/16)\times10^{-3}$ Joules/bit at transmitter
  $(1/16)\times 10^{-8}$ at receiver
- Eb/N0 at receiver decreases to $10^3/160 = 7.96$dB
- By waterfall graph, beP increases to 2×10^{-4}
- By PESQ graph, PESQ reduces to 2.5.

$\therefore$ Reducing transmit power from 1 to 0.8 Watt increases battery life by 1.25 hrs, but reduces speech quality from PESQ 3.4 to 2.5.

Task 3.1:Conclusions & question

- Relationship between battery life at mobile phone transmitter and speech quality at receiver has now been demonstrated, when there is no FEC.
- Can FEC improve this result?

Task 3.2: Simple FEC coding

- A very simple FEC scheme.
- Send each bit 3 times.
- Block coding scheme much easier than Hamming.
- Use majority voting at receiver.
- Is this an efficient scheme?

Task 3.3: ARQ

- Append 8-bit CRC to bit array representing some text.
- Transmit over channel.
- Vary the BEP from 0.0001 to 0.1.
- Repeat transmission if CRC fails.
- Try up to 9 times & then give up.
- Is this efficient?
- Can it be improved?

Task 3.4: Convolutional coding

- Convolutional coding applied to speech
- Apply Viterbi decoder.
- Better than (3,1) repetition?

Task 3.5: Conv coding & ARQ

- Convolutional coding with ARQ applied to text.
- Message has BOTH convolutional coding & CRC.
- Decode using Viterbi decoder.
- Then check CRC to see whether Viterbi decoder has corrected all errors.
- Request retransmission if necessary.
- ARQ on its own inefficient in mobile systems because retransmissions are expensive.
- This combined approach is widely used.

Summary of Task 3

- Relationship between energy & bit-error rate demonstrated.
- Also relationship between BER & speech quality.
- Simple (3,1) repetition FEC scheme investigated.
- ARQ implemented for text
- Convolutional coding applied to speech
- Convolutional coding combined with ARQ applied to text