System-Compatible Robustness Improvement for New Generation DECT Decoders by G.722 Soft-Decision Decoding

Universidad de Granada

Domingo López-Oller †, Sai Han‡, Angel M. Gomez †, José Luis Pérez-Córdoba†, Tim Fingscheidt ‡

† Department of Signal Theory, Telematics and Communications, University of Granada (Spain)

‡ Institute for Communications Technology, Technische Universität Braunschweig (Germany)

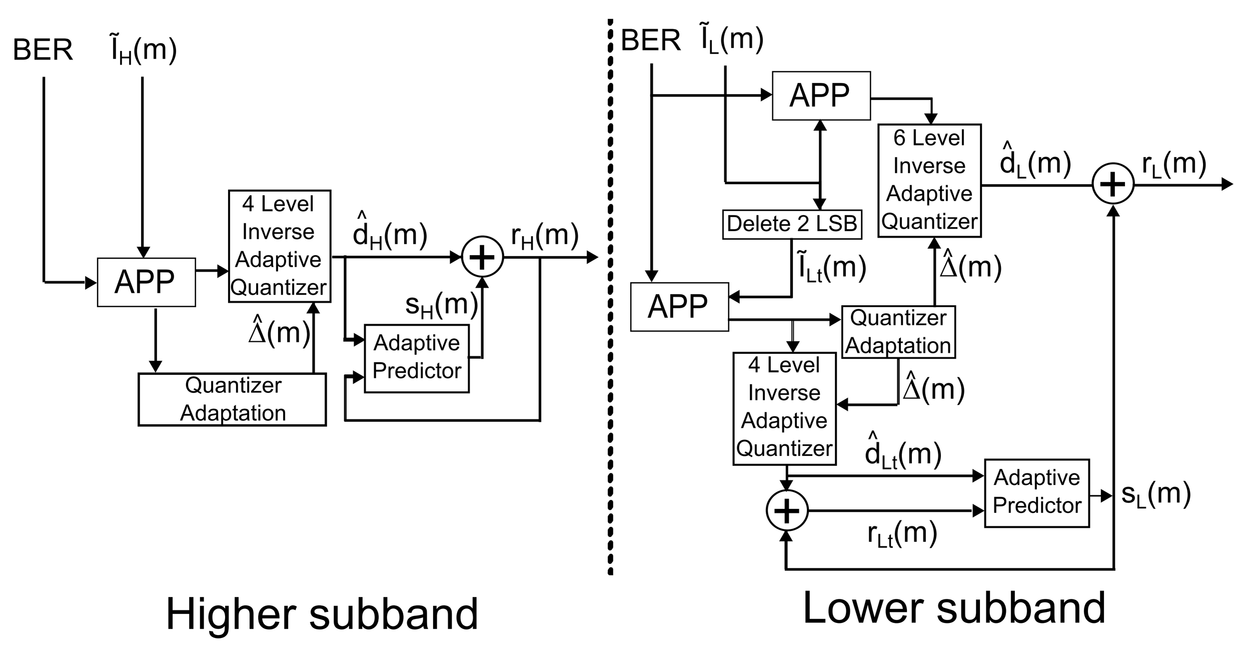
Technische Universität Braunschweig

Motivation

- Wireless communications has gained popularity in the last years due to new wireless technologies.
- DECT technology has reached 73% of market in VoIP services for WLAN networks.
- With **NG-DECT** a higher speech quality is achieved using the **G.722** speech codec (up to 64 kbps).
- **Problem:** Wireless transmission is error-prone, resulting in degradation of speech quality. Moreover, this error can generate an error propagation along the next correctly received samples during the decoding stage.
- **Our proposal:** We estimate each corrupted sample in a frame which minimizes these errors by using a **soft-decision decoding** technique and obtain a robust speech codec under erasure channel conditions.

Novel G.722 decoding scheme by Soft-Decision Decoding

- Novel ADPCM scheme with **soft-decision decoding** applied to the G.722 speech codec



- This technique is based on the a posteriori probability (APP) from the received sample $\tilde{\mathbf{I}}(m)$ and the channel reliability information (BER):

$$P(\mathbf{I}^{(j)}|\tilde{\mathbf{I}}(m)) = C \cdot P(\tilde{\mathbf{I}}(m)|\mathbf{I}^{(j)}) \cdot P(\mathbf{I}^{(j)}),$$

where C is a normalization constant, $P(\mathbf{I}^{(j)})$ is the a priori knowledge and $P(\tilde{\mathbf{I}}(m)|\mathbf{I}^{(j)})$ is the transition probability.

- An estimated parameter $\mathbf{v}$ can be obtained using an MMSE estimation method as:

$$\mathbf{v} = \sum_{j=0}^{2^M-1} \mathbf{v}^{(j)} P(\mathbf{I}^{(j)}|\tilde{\mathbf{I}}(m))$$

- The scale factors for each subband are obtained as:

$$\widehat{\Delta}_R(m) = \sum_{j=0}^{2^M-1} \left(\Delta_R(m)^{(j)} P(\mathbf{I}^{(j)}|\tilde{\mathbf{I}}(m-1)\right) =$$
$$2^K \cdot \Delta_{\min} \cdot \sum_{j=0}^{2^M-1} \left(\left(2^{\beta\nabla_R(m-1)+W_R[\mathbf{I}^{(j)}]}\right) P(\mathbf{I}^{(j)}|\tilde{\mathbf{I}}(m-1))\right)$$

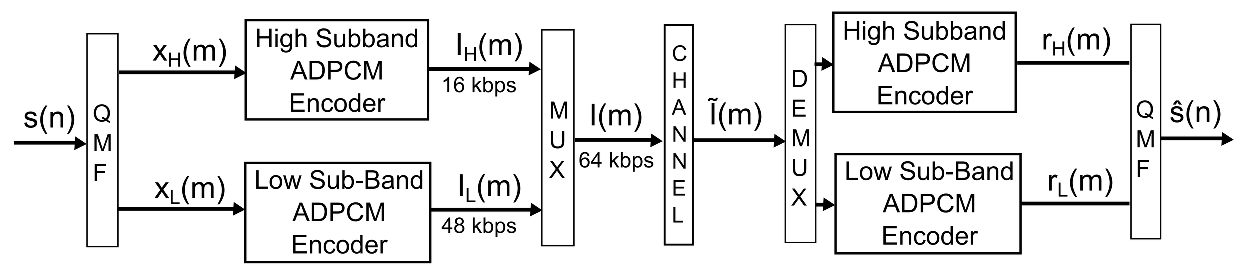
- The quantized difference signals for each subband are also obtained as:

$$\widehat{d}_L(m) = \left(\sum_{j=0}^{2^6-1} (Q6^{-1}[\mathbf{I}^{(j)}] \cdot \mathrm{sgn}(\mathbf{I}^{(j)}) \cdot P(\mathbf{I}^{(j)}|\tilde{\mathbf{I}}(m))\right) \widehat{\Delta}_L(m);$$
$$\widehat{d}_{Lt}(m) = \left(\sum_{j=0}^{2^4-1} (Q4^{-1}[\mathbf{I}^{(j)}] \cdot \mathrm{sgn}(\mathbf{I}^{(j)}) \cdot P(\mathbf{I}^{(j)}|\tilde{\mathbf{I}}(m))\right) \widehat{\Delta}_L(m);$$
$$\widehat{d}_H(m) = \left(\sum_{j=0}^{2^2-1} (Q2^{-1}[\mathbf{I}^{(j)}] \cdot \mathrm{sgn}(\mathbf{I}^{(j)}) \cdot P(\mathbf{I}^{(j)}|\tilde{\mathbf{I}}(m))\right) \widehat{\Delta}_H(m).$$

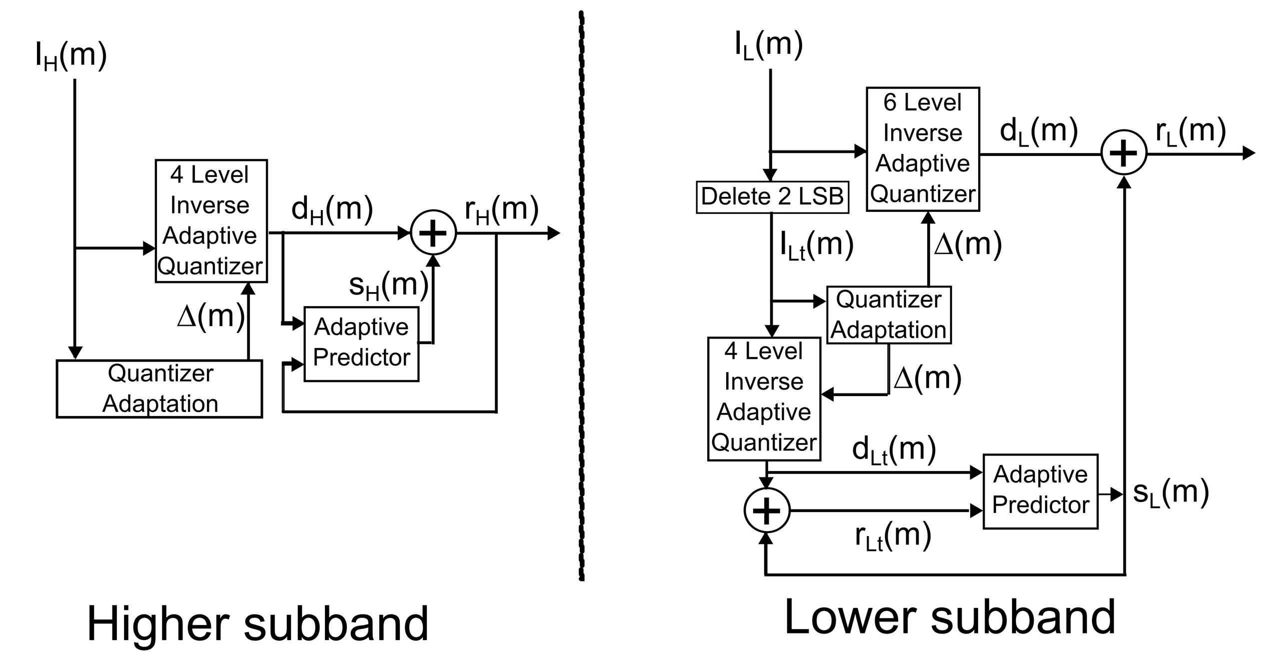
- **Advantage:** Our proposal is applied in a standard-compliant way under error-free channels.

G.722 Standard Decoding procedure

- G.722 transmission scheme based on an ADPCM subband encoding:



- ADPCM decoder scheme for each subband:



- Several parameters can be modified as a consequence of a corrupted sample ($\tilde{I}(m)$) in a frame in one or both subbands:

Adaptive scale factors:

$$\Delta_L(m) = 2^{[\nabla_L(m)+2]} \cdot \Delta_{\min},$$
$$\Delta_H(m) = 2^{[\nabla_H(m)]} \cdot \Delta_{\min},$$
$$\text{with } \nabla_R(m) = \beta\nabla_R(m-1) + W_R[\tilde{\mathbf{I}}_R(m-1)].$$

Quantized differential signals:

$$d_L(m) = Q6^{-1}[\tilde{\mathbf{I}}_L(m)] \cdot \Delta_L(m) \cdot \mathrm{sgn}(\tilde{\mathbf{I}}_L(m)),$$
$$d_{Lt}(m) = Q4^{-1}[\tilde{\mathbf{I}}_{Lt}(m)] \cdot \Delta_L(m) \cdot \mathrm{sgn}(\tilde{\mathbf{I}}_{Lt}(m)),$$
$$d_H(m) = Q2^{-1}[\tilde{\mathbf{I}}_H(m)] \cdot \Delta_H(m) \cdot \mathrm{sgn}(\tilde{\mathbf{I}}_H(m)).$$

- These errors cause a desynchronization with the encoder, so an **error propagation** occurs.

Results

Simulation Setup:

- **Database:** NTT Database.
- **Channel model:**
  - Rayleigh fading channel model with a BFSK modulation (user speed 0.3 and 3 m/s).
  - A different bit error rate (BER) is considered for each frame ($E_b/N_0 \in [0, 30]$ dB):

$$\mathrm{BER} = \frac{1}{2} \cdot \mathrm{erfc}\left(\sqrt{\alpha^2 \frac{E_b}{2N_0}}\right)$$

- **Tests:**
  - Hard-decision decoding (**HD**).
  - Hard-decision decoding with PLC algorithm when BER >10% (**PLC**).
  - Soft-decision decoding proposals: (**SD_H**), (**SD_L**) and (**SD_LH**).

- **Results:**