OFDM (DMT) Bit and Power Loading for Unequal Error Protection

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Outline

1. Motivations
   - Why Unequal Error Protection (UEP)?
   - Why UEP Physical Transport?
2. UEP: Bit-Loading
   - Previous Work
   - Proposed UEP Bit-Rate Maximization
3. Channel Model
   - Noise Environment
4. Simulation Results
   - UEP Performance: SER Analysis
   - Bit and Power Loading
5. Conclusions

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Realizing UEP

- Source encoders of some applications deliver data of different importance.
- The different error sensitivities of different communication devices, e.g., PDAs, laptops, $\cdots$.
- Matching the channel variations to enhance performance and throughput.

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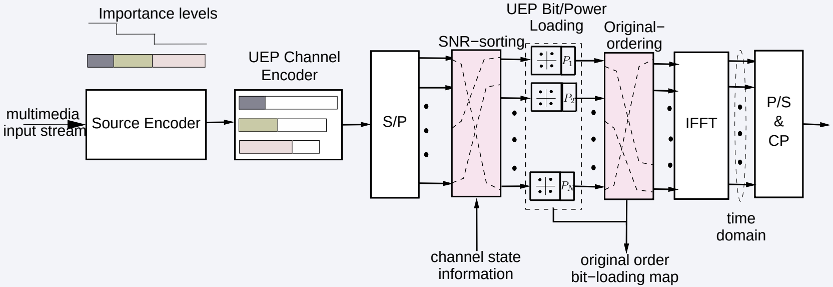

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- Reduce effort and complexity
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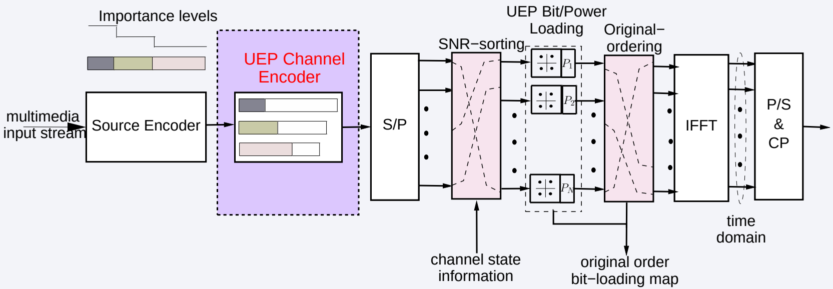

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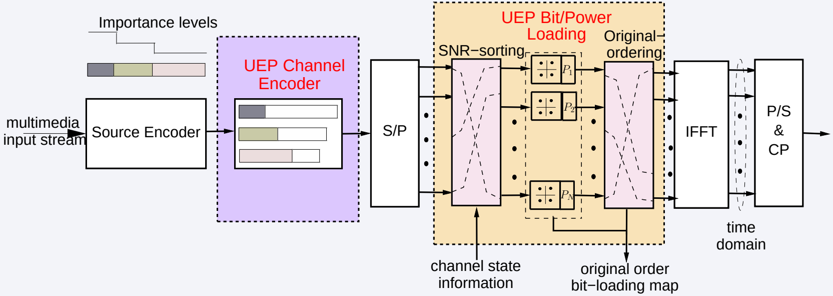

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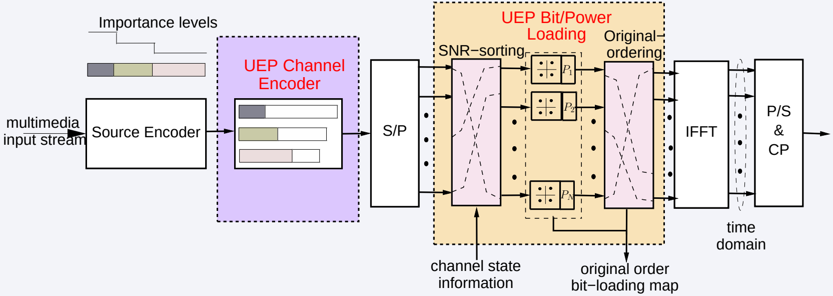

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Bit-Loading Algorithms

Bit-Loading solutions:

- Optimum: add bits to the locations of minimum incremental power, e.g.: Hughes-Hartogs and Campello
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Bit-Loading by Chow et. al.:

$$b_k = \log_2\left(1 + \frac{\text{SNR}_k}{\gamma}\right)$$

Bit-Rate Maximization Problem:

$$\max_{b \in Z}\left\{B_{\text{tot}} = \sum_{k=0}^{N-1} b_k\right\}$$

$$\text{subject to } \sum_{k=0}^{N-1} P_k(b_k) < P_T \ ,$$

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Quantization Error:

$$\begin{aligned} \hat{b}_k &= \lfloor b_k + 0.5 \rfloor_0^{b_{\max}} \\ \Delta b_k &= b_k - \hat{b}_k \end{aligned}$$

Modifications to Bit-Loading by Chow et. al.

Problem definitions

- N_g levels of protections with noise margins γ_j
- Noise margin step size $\Delta\gamma_j$
- Target-rates T_j for each class
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Modified bit-loading:

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Input: SNR$_{k,j}$ in k^{th} subcarrier of j^{th} class, N, N_g, B_T, T_j, and $\Delta\gamma$
Output: γ_j, average probability of error $\overline{\mathscr{P}_{ej}}$, and bit-loading

- Compute b_{kj} using γ_j ($\gamma_j = \gamma_0 - j \cdot \Delta\gamma$).
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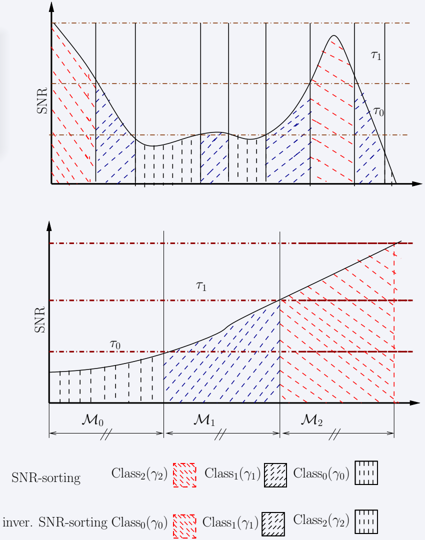

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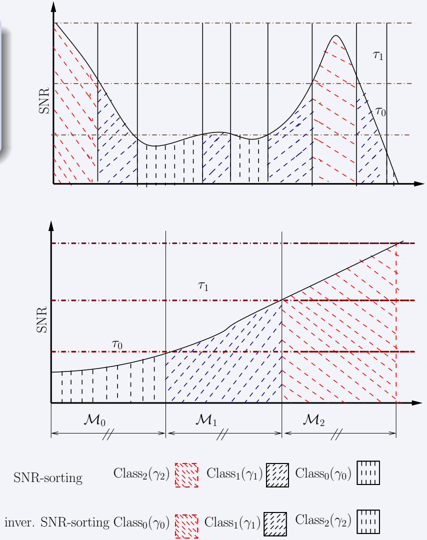
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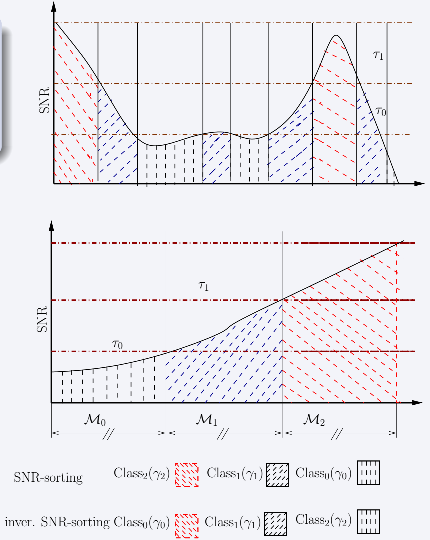
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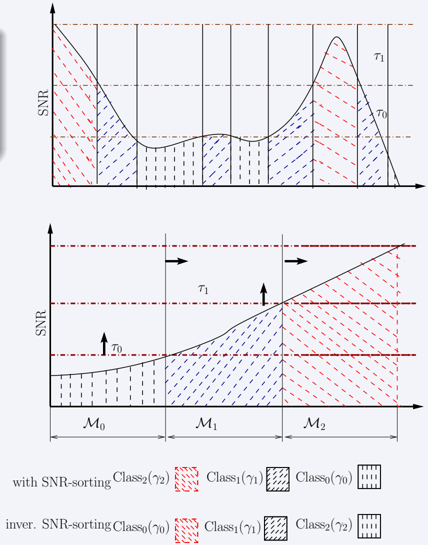
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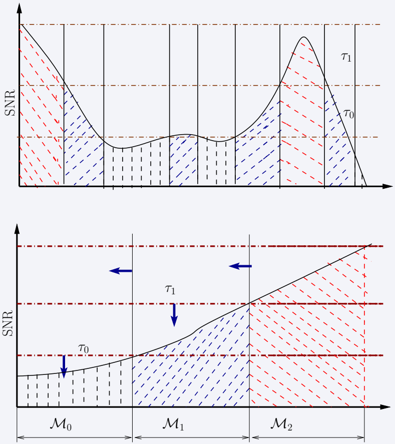

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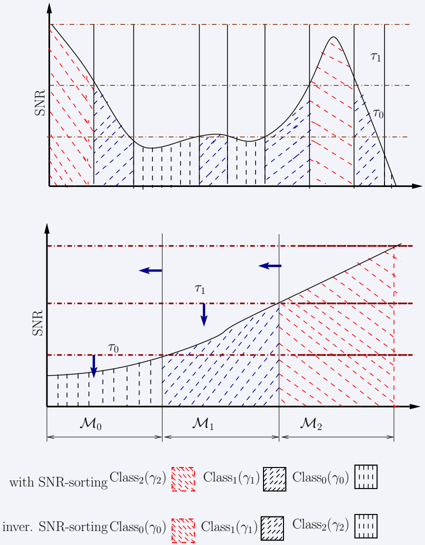
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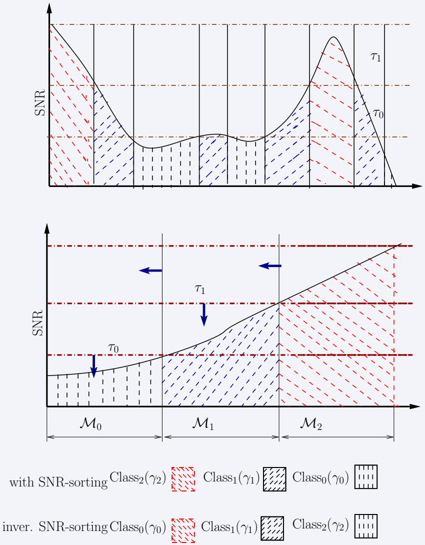
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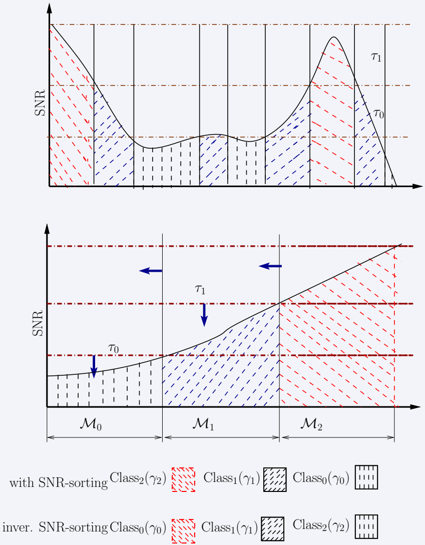
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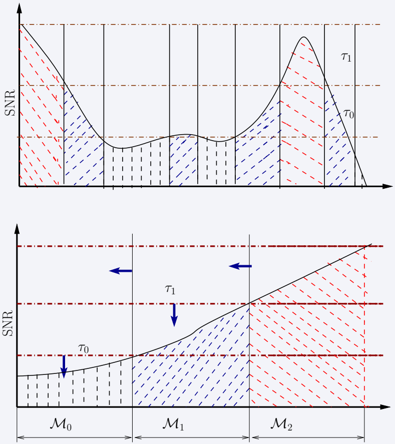

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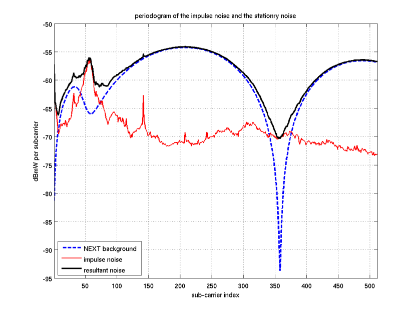
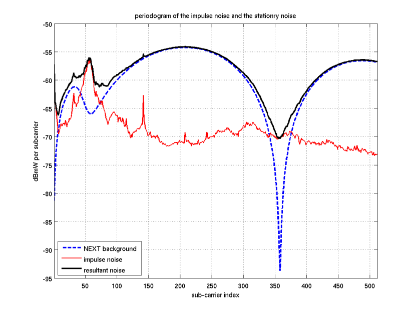


- ADSL2*plus* with 512 subcarriers is considered for this channel.
- A wireline cable of diameter 0.4 mm and 2 km length is assumed.
- A combination of T1 + HDSL NEXT and -130 dBm/Hz AWGN is used for the bit-loading.
- Additionally, real measured impulse noise is introduced after bit allocation.



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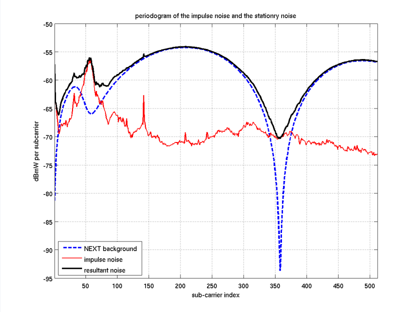

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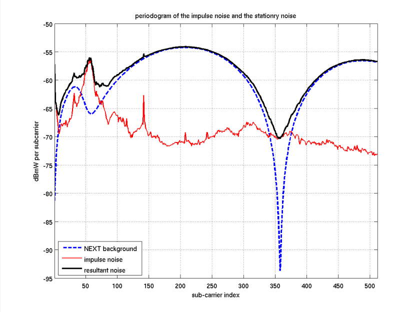

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SER for Stationary and Non-stationary Noise

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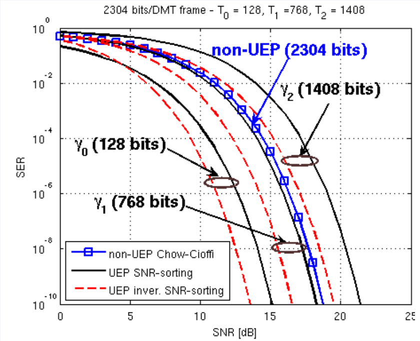
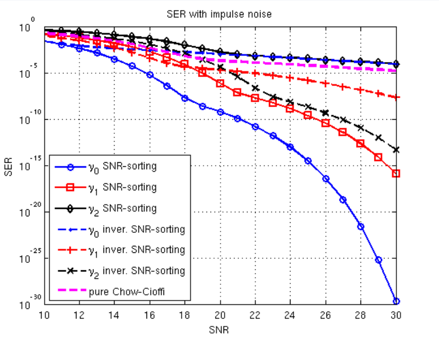
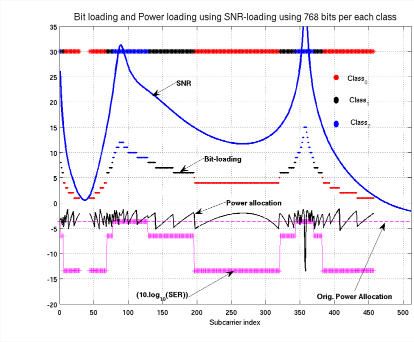
SER for non-stationary noise



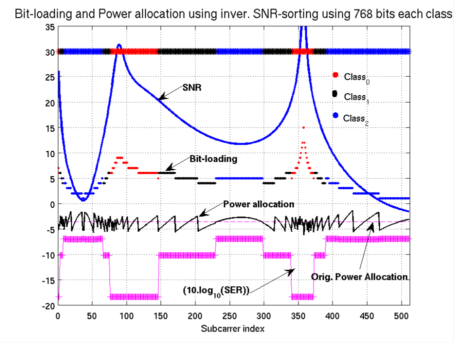


UEP bit-loading and power-allocation:

SNR-Sorting Scheme



Inverse SNR-Sorting Scheme



Outline

1. Motivations
   - Why Unequal Error Protection (UEP)?
   - Why UEP Physical Transport?
2. UEP: Bit-Loading
   - Previous Work
   - Proposed UEP Bit-Rate Maximization
3. Channel Model
   - Noise Environment
4. Simulation Results
   - UEP Performance: SER Analysis
   - Bit and Power Loading
5. Conclusions

Conclusions

- We described an UEP bit-allocation scheme as an extension of the algorithm by Chow et al..
- Allows arbitrary margin definitions and bit-rates according to the priorities.
- SNR-sorting will ensure that the high-priority class will still be well protected even under non-stationary noise.

Modified bit-loading:

$$\begin{aligned} b_{k,j} &= \log_2\left(1+\frac{\mathsf{SNR}_{k,j}}{\gamma_j}\right) \\ \hat{b}_{k,j} &= \lfloor b_{k,j}+0.5\rceil_0^{b_{\max}} \\ \Delta b_{k,j} &= b_{k,j}-\hat{b}_{k,j} \end{aligned}$$

Open points:

Possible mixed allocation and hierarchical modulation.

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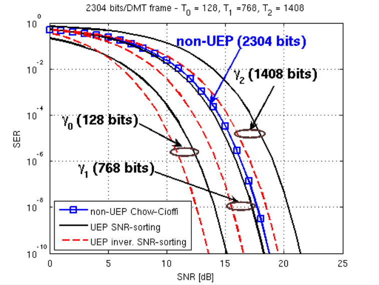

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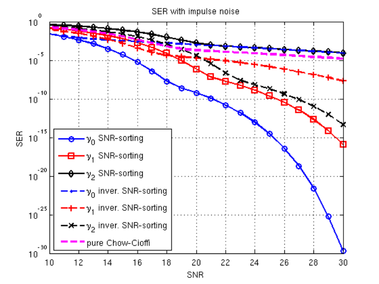

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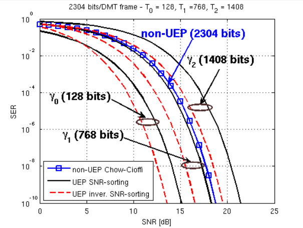

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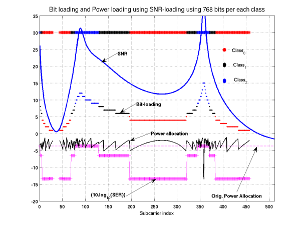

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Thank you!