The Serial Concatenation of Rate-1 Codes Through Uniform Random Interleavers

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Union Bounds on Performance

- Rate r = k/n, linear block code C
- Input Output Weight Enumerator Function (IOWEF):

 $A_{w,h} \stackrel{\mathrm{def}}{=} \#$ codewords, input weight w, output weight h

 \bullet Union bound on word error probability $P_{\it W}$ (binary-input, memoryless channel, maximum-likelihood decoding):

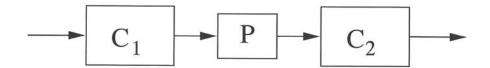
$$P_W \le \sum_{h=1}^n \sum_{w=1}^k A_{w,h} z^h$$

- z is channel dependent; e.g., for Gaussian channel, $z=e^{-r(E_b/N_0)}$.
- ullet For ensembles, replace $A_{w,h}$ by average IOWEF $\overline{A_{w,h}}$



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Serial Concatenation through a Uniform Interleaver



- Let C_1 , C_2 be (n_1,k_1) , (n_2,k_2) linear block codes with $n_1=k_2$, and IOWEFs $A_{w,h}^{(1)}$, $A_{w,h}^{(2)}$.
- Let C be the (n_2,k_1) code obtained by serial concatenation of C_1 and C_2 through a uniform interleaver of size n_1 , with average IOWEF $A_{w,h}$:

$$A_{w,h} = \sum_{h_1=0}^{n_1} A_{w,h_1}^{(1)} \cdot \frac{A_{h_1,h}^{(2)}}{\begin{pmatrix} n_1 \\ h_1 \end{pmatrix}}$$



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Repeat-Accumulate (RA) Codes (Divsalar, et al., Allerton'98)



- Repeat input block $x_1x_2\cdots x_N$ a total of q times.
- Permute with random interleaver P of size n=qN.
- Accumulate over block:

$$u_1u_2\cdots u_n \rightarrow v_1v_2\cdots v_n$$

$$v_1 = u_1$$

$$v_2 = u_1 + u_2$$

$$\vdots$$

$$v_n = u_1 + \cdots + u_n$$



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