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Allerton Conference September 22-24, 1999



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Outline

- Union Bounds and Code Performance
- Serial Concatenation and Repeat-Accumulate (RA) Codes
- Serial Concatenation of Rate-1 Codes
- Repeat-Accumulate-Accumulate (RAA) Codes
- Summary



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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

 Union bound on word error probability P_W (binary-input, memoryless channel, maximum-likelihood decoding):

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

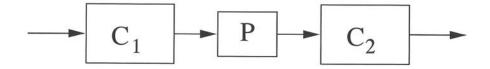
- z is channel dependent; e.g., for Gaussian channel, $z = e^{-r(E_b/N_0)}$.
- For ensembles, replace $A_{w,h}$ by average IOWEF $\overline{A_{w,h}}$



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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 $A_{w,h}$:

$$A_{w,h} = \sum_{h_{1=0}}^{n_{1}} A_{w,h_{1}}^{(1)} \cdot \frac{A_{h_{1},h}^{(2)}}{\binom{n_{1}}{h_{1}}}$$



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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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