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

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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

Union Bounds on Performance

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

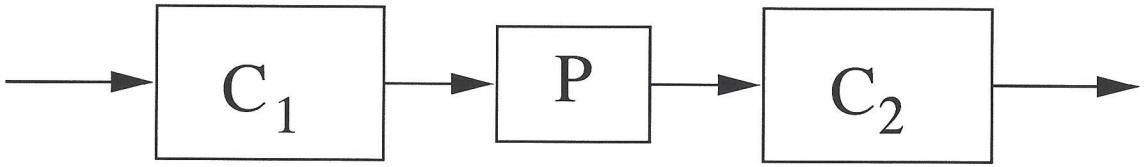
$$A_{w,h} \stackrel{\text{def}}{=} \#\text{ codewords, input weight } w\text{, output weight } h$$

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

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

- 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 $\overline{A_{w,h}}$

Serial Concatenation through a Uniform Interleaver

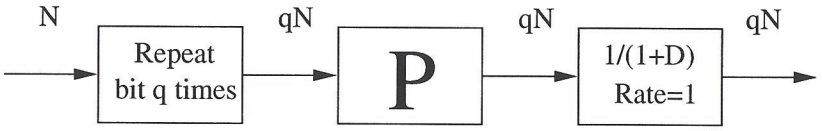


- Let C_1, C_2 be (n_1, k_1), (n_2, k_2) linear block codes with $n_1 = k_2$, and IOWEFs $A^{(1)}_{w,h}$, $A^{(2)}_{w,h}$.

- 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 $A_{w,h}$:

$$A_{w,h} = \sum_{h_1=0}^{n_1} A^{(1)}_{w,h_1} \cdot \frac{A^{(2)}_{h_1,h}}{\binom{n_1}{h_1}}$$

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



- Repeat input block $x_1 x_2 \cdots x_N$ a total of q times.
- Permute with random interleaver P of size $n = qN$.
- Accumulate over block:

$$u_1 u_2 \cdots u_n \rightarrow v_1 v_2 \cdots v_n$$

$$v_1 = u_1$$

$$v_2 = u_1 + u_2$$

$$\vdots$$

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

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