

# Simple LTC Good LDPC Codes

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## Abstract

We propose a new simple construction based on Tanner Codes, which yields a good LDPC testable code.

**ex1.** Find a simple description of the work-function algorithm in the case of uniform metric space.

**ex2.** Consider the following 3-point metric space,  $w(a, b) = 1$  and  $w(\cdot, c) = M$ . The initial configuration is  $\{b, c\}$  (2 servers). Show that randomized competitive ratio, for some value of  $M$  is  $> H_2 = 1 + \frac{1}{2}$ .

**Solution.** Define the following distribution:

$$\tilde{\sigma} = \begin{cases} (ab)^{\frac{M}{3}} & \text{w.p. } \frac{1}{2} \\ (ab)^{\frac{M}{3}} & \text{w.p. } \frac{1}{2} \end{cases}$$

**ex3.** Show that randomized marking algorithm cannot be  $c$ -competitive against the adaptive online adversary, for  $c = o(k)$ .

**Solution.** Assume by contradiction that there is a constant  $c > 1$ , and a randomized algorithm which is an  $c$ -competitive in the adaptive online setting. According to theorem that shown at class, If there is exists an  $\alpha$  competitive alg for an online problem in the non-adaptive setting and in addition there exists a  $\beta$  competitive algorithm for the same problem against adaptive online adversary, then it holds that there exists an algorithm which is  $\alpha\beta$  competitive against an offline adaptive adversary. Combine the fact that randomized can't help against such adversary we obtain that the deterministic competitive ratio is lower than  $\alpha\beta$ . As we know that a  $k$ -lowerbound for the deterministic regime and also a  $\log k$  solution using randomization against a non-adaptive adversary, we obtain that

$$\begin{aligned} \alpha\beta &\geq k \\ \Rightarrow \frac{k}{c} \log k &\geq k \end{aligned}$$

But for any  $k \leq \log 2^c$  we obtain the opposite direction. Which mean that there is a range of valid  $k$  that obtains a better ratio than the lower bound. And that is a contradiction.

**ex4 - Ski Rental.** At each step, the adversary decides either continue or stop. Stop terminate the game. If it continues, the online algorithm decides, either rent or buy. Rent costs 1 Buy costs  $M > 1$ . Design a primal-dual randomized online ski-rental algorithm with better than 2 competitive ratio.

**ex5.** Prove Yao's minimax principle.

$\forall \text{rand. } \tilde{\text{alg}} \exists \sigma$

$$\mathbf{E} [c_{\text{alg}}(\sigma) : \text{alg} \sim \tilde{\text{alg}}] \geq c \cdot c_{\text{base}}(\sigma)$$

$\Leftrightarrow \exists \text{rand. } \tilde{\sigma} \forall \text{alg}$

$$\mathbf{E} [c_{\text{alg}}(\sigma) : \sigma \sim \tilde{\sigma}] \geq c \mathbf{E} [c_{\text{base}}(\sigma) : \sigma \sim \tilde{\sigma}]$$

**Solution.** First direction, assume through contradiction that there exists a deterministic algorithm such that for all distributions  $\tilde{\sigma}$ :

$$\mathbf{E} [c_{\text{alg}}(\sigma) : \sigma \sim \tilde{\sigma}] < c \mathbf{E} [c_{\text{base}}(\sigma) : \sigma \sim \tilde{\sigma}]$$

And that holds, in particular, for distribution  $\tilde{\sigma}$  which supported by a single  $\sigma$ . Hence, by the fact that any deterministic algorithm is also a randomized algorithm, set it to be  $\tilde{\text{alg}}$  and that immediately yields a contradiction. It left to show the second direction, By the monotonic property of random variables we have that for any distribution  $\tilde{\sigma}$ :

$$\begin{aligned} &\mathbf{E} [\mathbf{E} [c_{\text{alg}}(\sigma) : \sigma \sim \tilde{\sigma}] : \text{alg} \sim \tilde{\text{alg}}] \\ &\geq c \cdot \mathbf{E} [\mathbf{E} [c_{\text{base}}(\sigma) : \sigma \sim \tilde{\sigma}] : \text{alg} \sim \tilde{\text{alg}}] \\ &\mathbf{E} [\mathbf{E} [c_{\text{alg}}(\sigma) : \text{alg} \sim \tilde{\text{alg}}] : \sigma \sim \tilde{\sigma}] \\ &\geq c \cdot \mathbf{E} [\mathbf{E} [c_{\text{base}}(\sigma) : \text{alg} \sim \tilde{\text{alg}}] : \sigma \sim \tilde{\sigma}] \\ &\mathbf{E} [\mathbf{E} [c_{\text{alg}}(\sigma) : \text{alg} \sim \tilde{\text{alg}}] : \sigma \sim \tilde{\sigma}] \\ &\geq c \cdot \mathbf{E} [c_{\text{base}}(\sigma) : \sigma \sim \tilde{\sigma}] \end{aligned}$$

And by the fact that inequality of expectation between random variables follows an existence of atomic event on which the inequality holds, we obtain that there is must exist at least a single  $\sigma$  such that:

$$\mathbf{E} [\mathbf{E} [c_{\text{alg}}(\sigma) : \text{alg} \sim \tilde{\text{alg}}] : \sigma \sim \tilde{\sigma}] \geq c \cdot \mathbf{E} [c_{\text{base}}(\sigma) : \sigma \sim \tilde{\sigma}]$$

And that ends the proof.