Understanding Quantumness And Testability.

D. Ponarovsky[1]

Master-Exam-Huji.

Faculty of Computer Science
Hebrew University of Jerusalem

Today.

- Brif Review of Coding.

Today.

- Brif Review of Coding.
- Quantum Error Correction Codes.

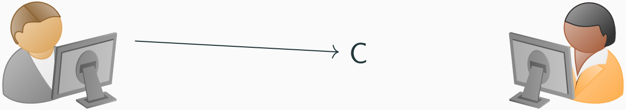
Today.

- Brif Review of Coding.
- Quantum Error Correction Codes.
- Good Classical Locally Testabile Codes and Good Qauntum LDPC.

Introduction.

The work assumes only a basic knowledge of linear algebra and combinatorics. So we believe that every computer science graduate will be able to enjoy reading it, understand the subject very well, and use it as a gateway for starting research in the field.

Coding.



Coding.

Can we come up with a code that tolerates $*$ bits flip?

Coding.

Definition

Let $n \in \mathbb{N}$ and $\rho, \delta \in (0,1)$. We say that C is a **binary linear code** with parameters $[n, \rho n, \delta n]$. If C is a subspace of $\mathbb{F}_2^n$, and the dimension of C is at least ρn. In addition, we call the vectors belong to C *codewords* and define the distance of C to be the minimal number of different bits between any codewords pair of C.

Coding.

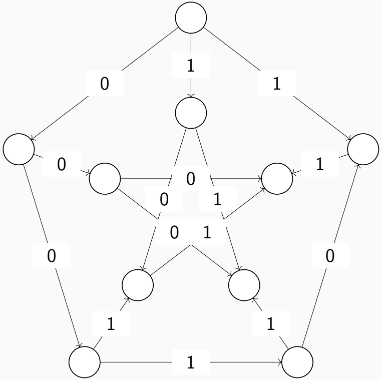
Definition

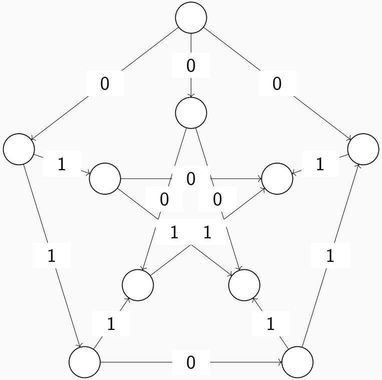
A **family of codes** is an infinite series of codes. Additionally, suppose the rates and relative distances converge into constant values ρ, δ. In that case, we abuse the notation and call that family of codes a code with $[n, \rho n, \delta n]$ for fixed $\rho, \delta \in [0, 1)$, and infinite integers $n \in \mathbb{N}$.

Definition

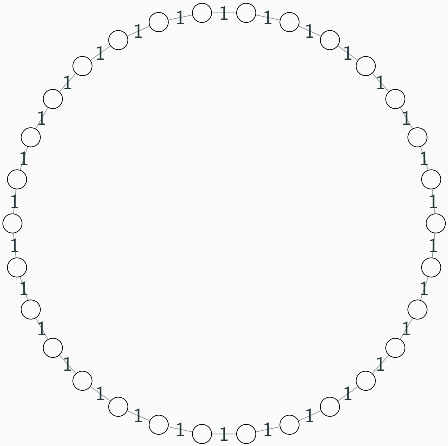
We will say that a family of codes is a **good code** if its parameters converge into positive values.

Coding.





Coding.



Quantum Error Correction Codes.

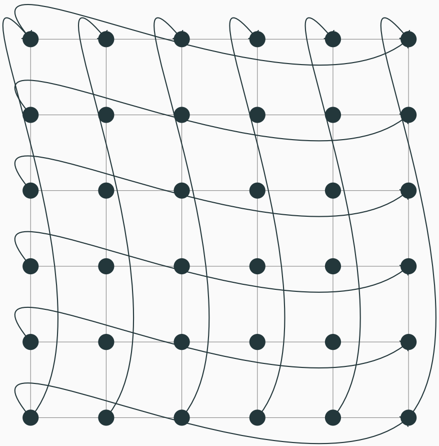
Quantum Error Correction Codes.

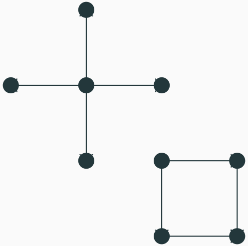
Definition (CSS Code)

Let C_X, C_Z classical linear codes such that $C_Z^{\perp} \subset C_X$ define the $Q\left(C_X, C_Z\right)$ to be all the code words with following structure:

$$|\mathbf{x}\rangle := |x + C_Z^{\perp}\rangle = \frac{1}{\sqrt{C_Z^{\perp}}} \sum_{z \in C_Z^{\perp}} |x + z\rangle$$

Quantum Error Correction Codes.



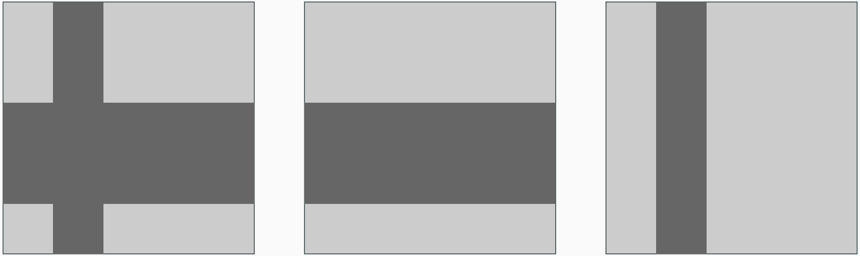


Definition (w-Robustness)

Let C_A and C_B be codes of length Δ with minimum distance $\delta_0\Delta$. $C = \left(C_A^\perp \otimes C_B^\perp\right)^\perp$ will be said to be w-robust if for any codeword $c \in C$ of weight less than w, it follows that c can be decomposed into a sum of $c = t + s$ such that $t \in C_A \otimes \mathbb{F}^B$ and $s \in \mathbb{F}^A \otimes C_B$, where s and t are each supported on at most $\frac{w}{\delta_0\Delta}$ rows and columns. For convenience, we will denote by B' (A') the rows (columns) supporting t (s) and use the notation $t \in C_A \otimes \mathbb{F}^{B'}$.

Quantum Error Correction Codes.

$$c \in \underbrace{\left(C_A^{\perp} \otimes C_B^{\perp}\right)^{\perp}} = \underbrace{t \in C_A \otimes \mathbb{F}^B} + \underbrace{s \in \mathbb{F}^A \otimes C_B}$$



Quantum Error Correction Codes.

Quantum Error Correction Codes.

Quantum Error Correction Codes.

Quantum Error Correction Codes.