Size depends on ~~Planck~~ Planck constant

classical bits $\Rightarrow$ 0 or 1

quantum $\Rightarrow$ $|0\rangle$ and $|1\rangle$

qbit

qbit can be set

it state does not change

exponential growth

2^n n - number of qubits

2^n possible states

275 qubits →

more states than atoms in observable universe

$|x\rangle$ - state

$|\psi\rangle$

$\langle x|$ - transposed state (same as $|x\rangle$)

$|x, y, z\rangle$

$$\langle x| = \left(|x\rangle^T\right)^* = |x\rangle^\dagger$$

$| \rangle$ - ket
$\langle |$ - bra
} vector

$\langle | \rangle$ - braket - number

$$|x\rangle = a|0\rangle + b|1\rangle$$

$$|0\rangle = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \qquad |1\rangle = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$|x\rangle = \begin{bmatrix} a \\ b \end{bmatrix}$$

$$\langle x| = \begin{bmatrix} a^*, b^* \end{bmatrix}$$

$$|a|^2 + |b|^2 = 1$$

normalizatia

Measurement:

$$|x\rangle = a|0\rangle + b|1\rangle$$

$$P_{|x\rangle}(0) = |a|^2$$

$$P_{|y\rangle}(1) = |b|^2$$

$$\langle x|x\rangle = \begin{bmatrix} a^* & b^* \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix} =$$

$$= a^* a + b^* b = |a^2| + |b|^2 = \underline{1}$$

$$\langle 0 | 1 \rangle = [1, 0] \begin{bmatrix} 0 \\ 1 \end{bmatrix} = 0$$

$$\langle 0 | 0 \rangle = 1$$

$$P|x\rangle(0) = \frac{2}{3}$$

$$P|x\rangle(1) = \frac{1}{3}$$

$$|a|^2 = \frac{2}{3} \qquad |b|^2 = \frac{1}{3}$$

$$a = \frac{\sqrt{2}}{\sqrt{3}} \qquad b = \frac{1}{\sqrt{3}}$$

$$x = \frac{\sqrt{2}}{\sqrt{3}} |0\rangle + \frac{1}{\sqrt{3}} |1\rangle$$

$$\begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} a' \\ b' \end{bmatrix}$$

2 x 2 matrix

$$X = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$$ - negation

$$X\,|0\rangle = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} = |1\rangle$$

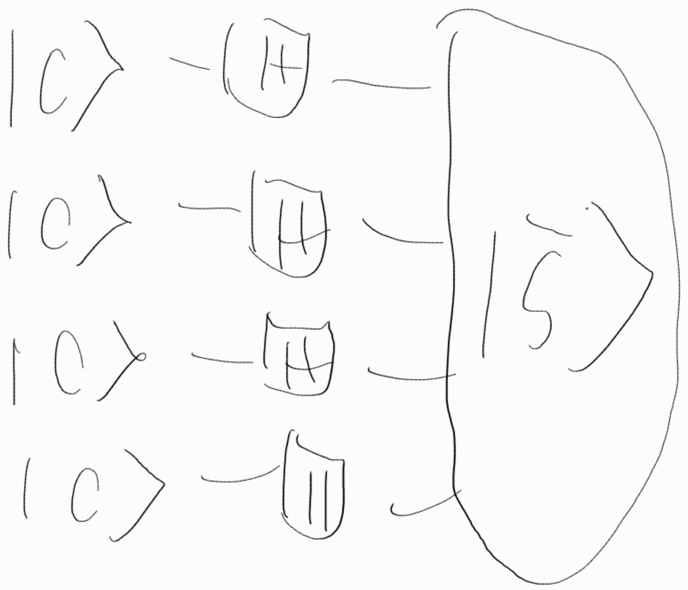
$$X \equiv \oplus$$

Hadamard gate (introduces superposition):

$$H = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

$$H|0\rangle = \frac{1}{\sqrt{2}}\begin{bmatrix}1 & 1\\ 1 & -1\end{bmatrix}\begin{bmatrix}1\\ 0\end{bmatrix} = \frac{1}{\sqrt{2}}\begin{bmatrix}1\\ 1\end{bmatrix} = \begin{bmatrix}\frac{1}{\sqrt{2}}\\ \frac{1}{\sqrt{2}}\end{bmatrix} = \underline{\frac{1}{\sqrt{2}}|0\rangle + \frac{1}{\sqrt{2}}|1\rangle}$$

superposition



superposition of

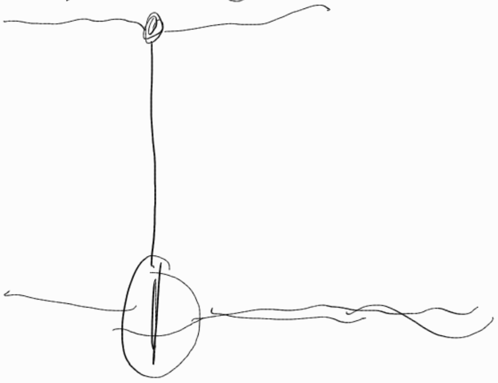
$2^4 \to 16$

amplify solution state and

make histogram to get solution

CNOT

source qubit



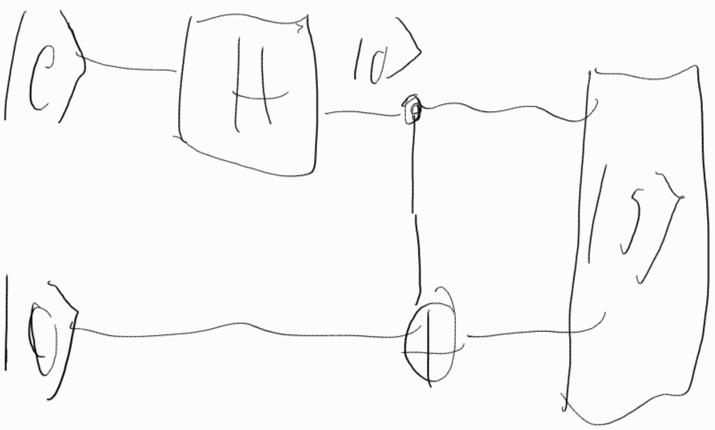
target qubit

if source i $|0\rangle$ then do nothing

if source i $|1\rangle$ applying negation

CNOT
controlled not

Bell's state



0 1

0 1

Synchronization $|S\rangle = \frac{1}{\sqrt{2}}\left(|00\rangle + |11\rangle\right)$

Hcmevrcall ;