DAY-10 TASK

Quantum Parallelism

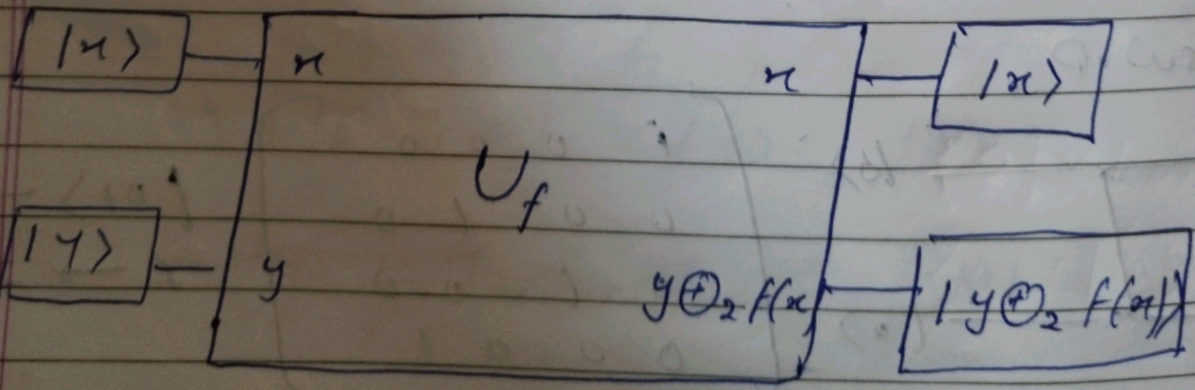
- Quantum Parallelism is a fundamental property of any quantum algorithm based on the quantum superposition principle

- Quantum Parallelism in quantum computational devices allows one to obtain several values of a certain function $f(x)$ in points $(x_1, x_2, \ldots x_n)$ simultaneously. It means that only one unitary logical operation is needed.

$$U_f : \{x_1, x_2, \ldots x_n\} \rightarrow \{f(x_1), f(x_2) \ldots f(x_n)\}.$$

Typical logical transformation (black box)

consider, for example: $f : \{0, 1\} \rightarrow \{0, 1\}$



$$U_f : |x, y\rangle \longrightarrow |x, y \oplus_2 f(x)\rangle$$

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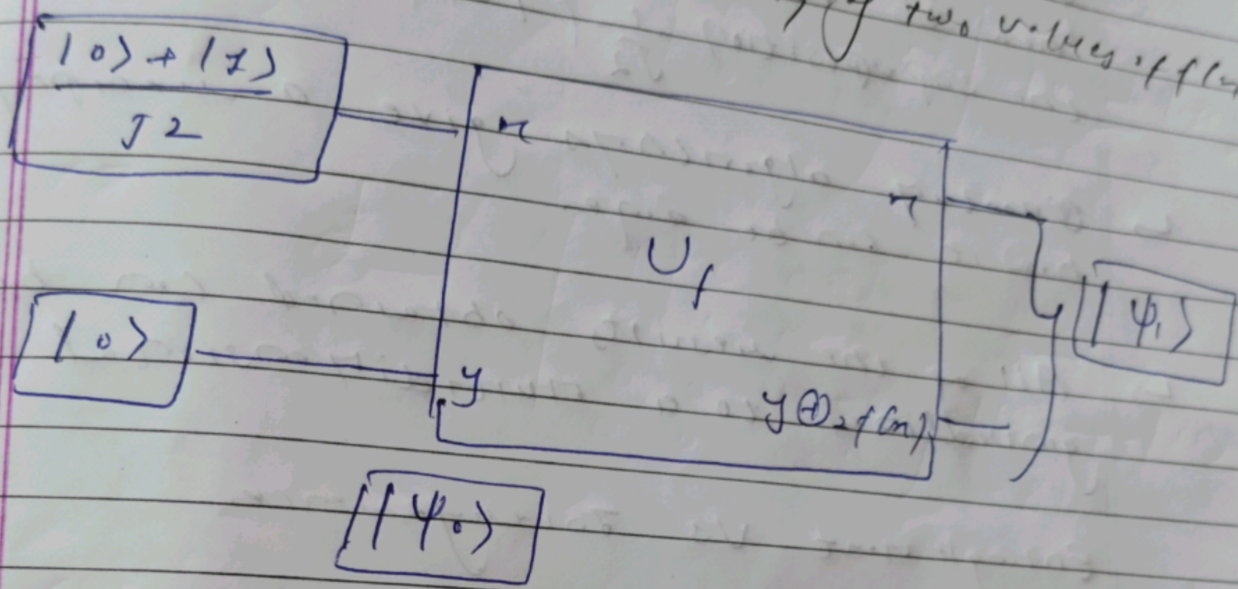
The first register (x) is called the data register. The second register (y and $y \oplus_2 f(x)$) is called the value register.

Simultaneous computation of two values of $f(x)$



$$U_f : \frac{1}{\sqrt{2}}|0,0\rangle + \frac{1}{\sqrt{2}}|1,0\rangle \rightarrow \frac{1}{\sqrt{2}}\left(|0,f(0)\rangle + |1,f(1)\rangle\right)$$

↳ unlike the classical parallel computations where several schemes for calculating the values of $f(x)$ are used, we only one logical operation.

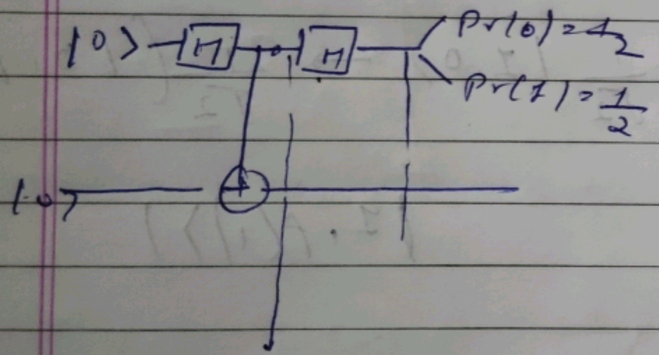
⇒ However, if we measure the superposition state, we will obtain only one value: $f(0)$ or $f(1)$. But this can be done by a classical computer too.

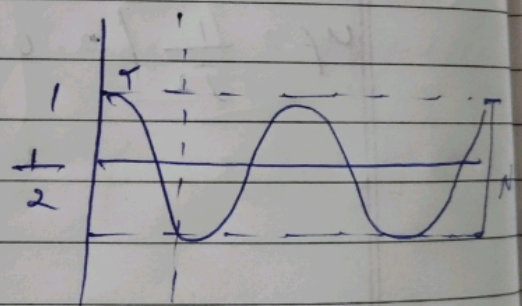
↳ To get the practical benefits from quantum computations we have to learn how to extract more information from the superposition $\frac{1}{\sqrt{2}}(|0, f(0)\rangle + |1, f(1)\rangle)$

↳ Quantum algorithms give a recipe for how it can be done.

↳ All of the results obtained can be generalized to a multidimensional case.

Entanglement vs Interference.





$\frac{1}{\sqrt{2}}(|00\rangle + e^{i\varphi}|11\rangle)$

$\langle 0|X|0\rangle = 0$

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

$\frac{1}{2}(|00\rangle + |10\rangle + e^{i\varphi}|01\rangle - e^{i\varphi}|11\rangle)$

$|0\rangle\left(\frac{|0\rangle + e^{i\varphi}|1\rangle}{2}\right) + |1\rangle\left(\frac{|0\rangle - e^{i\varphi}|1\rangle}{2}\right)$