Deutsch's Algorithm
Dataflow Computing

MAXELER Technologies
MAXIMUM PERFORMANCE COMPUTING

Abdulwahab Alkharashi
2016 Indiana University, Bloomington

Outline

- Problem Statement
- Motivation
- Example
- Quantum Circuit
- Implementation Steps

Problem Statement

- We are given a black box in (quantum computer) known as an oracle that implements some function ***f***$\{0,1\}^n \Rightarrow$ ***f***$\{0,1\}^n$
- Takes a binary as input and outputs 0 or 1
- Task is to decide whether ***f*** *constant* (0 on all inputs) or *balanced* (1 on all inputs)

Motivation

- Show such problem is hard to implement in classical computer and easy for quantum computer
- Use less number of quires or operation to solve the problem against deterministic approach
- Yields an oracle relative to show the complexity class differences

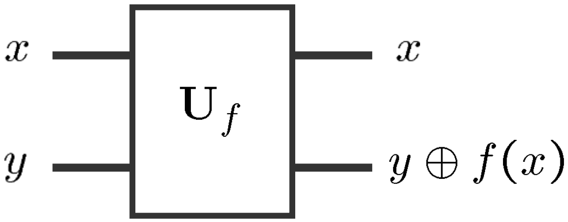
Example

two qubits

$$\alpha_0|00\rangle + \alpha_1|01\rangle + \alpha_2|10\rangle + \alpha_3|11\rangle$$

$$\begin{pmatrix} \alpha_0 \\ \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{pmatrix} \begin{array}{l} |00\rangle \\ |01\rangle \\ |10\rangle \\ |11\rangle \end{array}$$

Oracle



$$x, y, f(x) \in \{0, 1\}$$

Example $f(x) = x$:

$$\mathbf{U}_f = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}$$

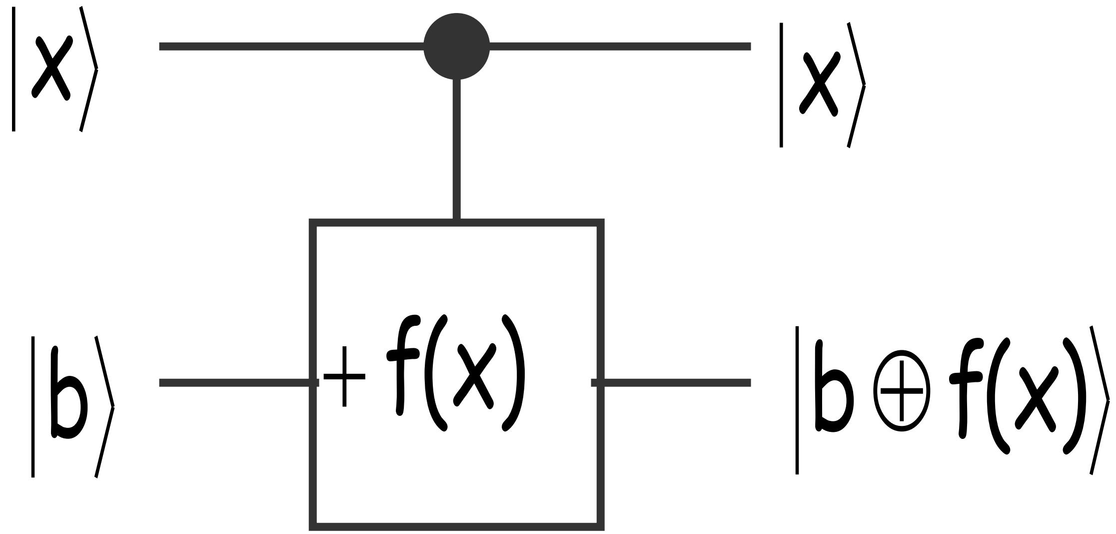
Four possible functions $f(x)$:

$$\underbrace{f(x) = 0 \quad f(x) = 1}_{\text{Constant functions}} \quad \underbrace{f(x) = x \quad f(x) = \bar{x}}_{\text{Balanced functions}}$$

Quantum Circuit

$$f : \{0,1\} \rightarrow \{0,1\}$$

Find $f(0) \oplus f(1)$ using only 1 evaluation of a reversible "black-box" circuit for f



Implementation Steps

- So, we can distinguish by measurement between first two circuits from bottom and second two circuits from bottom.
- This method is very general, we can build various oracles and check how they can be distinguished, by how many tests.
- In this case, we just need one test, but in a more general case we can have a decision tree for decision making.