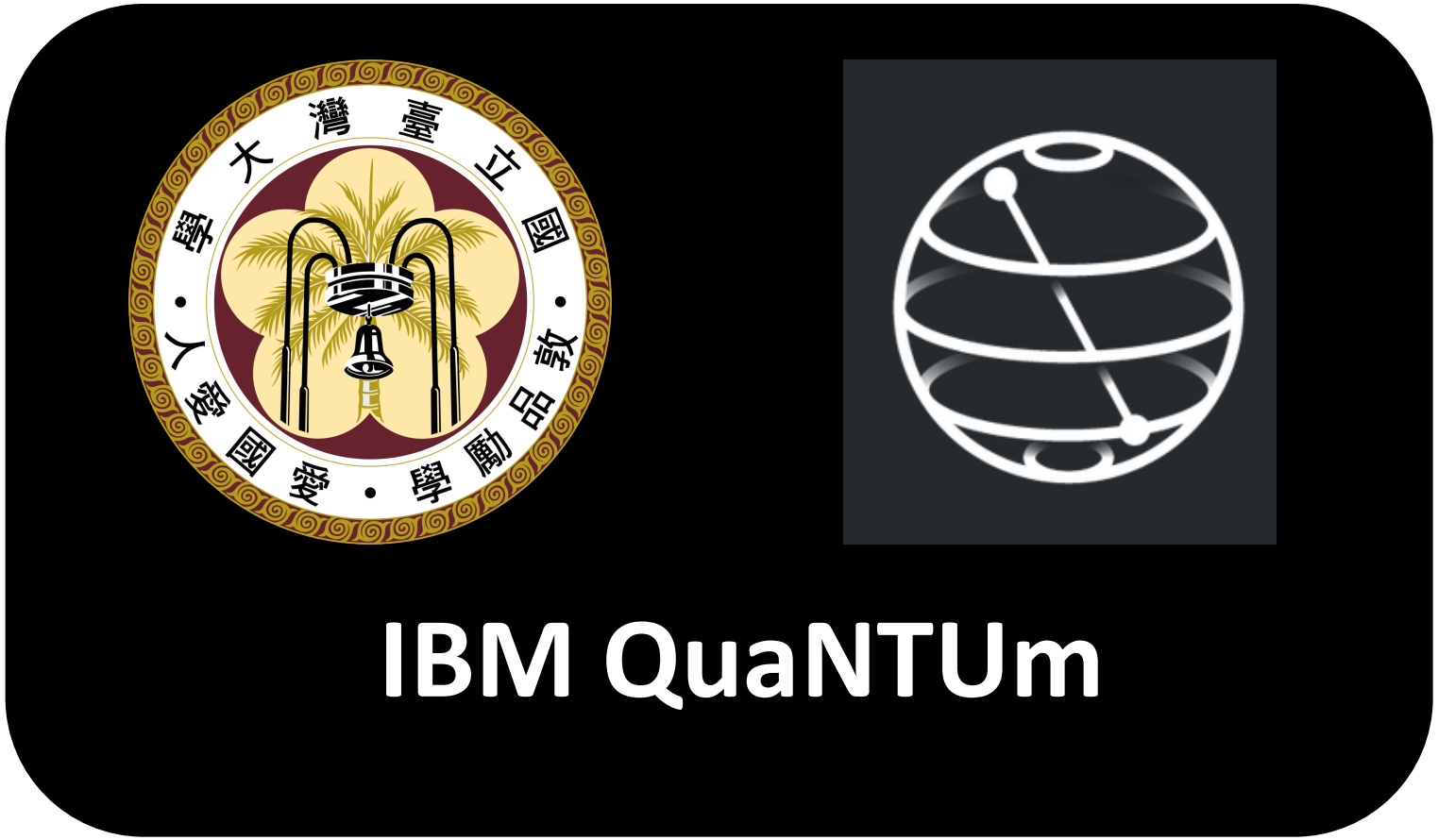
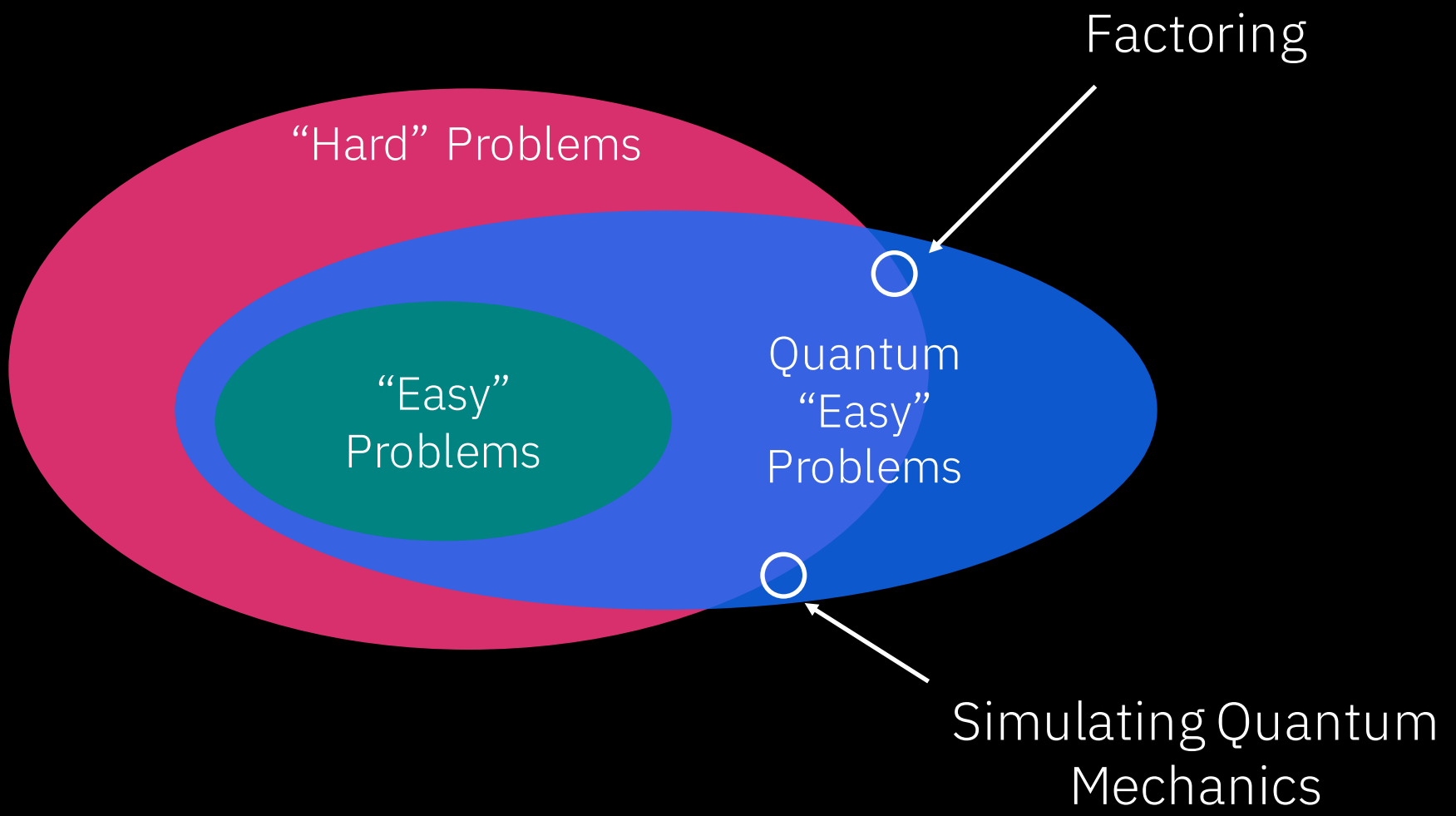
NTU – IBM Q Initial Workshop
@ Taiwan 2019



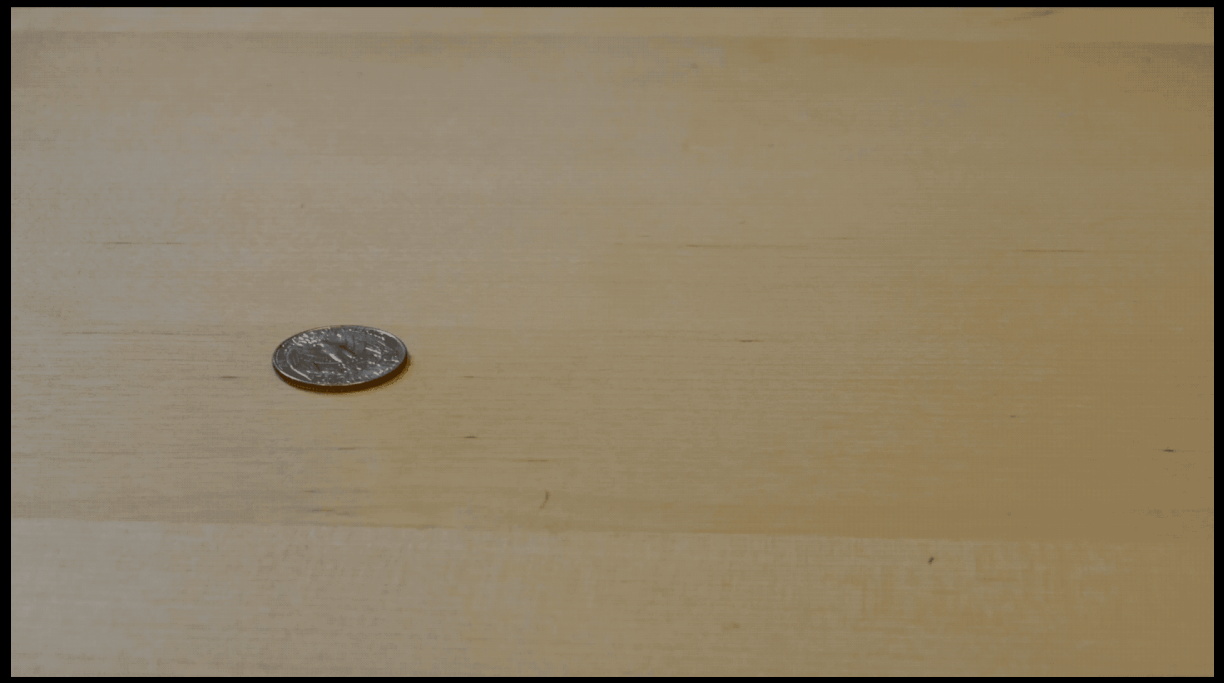
Rudy Raymond H.P. (IBM Research, Quantum Algorithms and Software)

Hard or memory intensive problems and quantum speedups



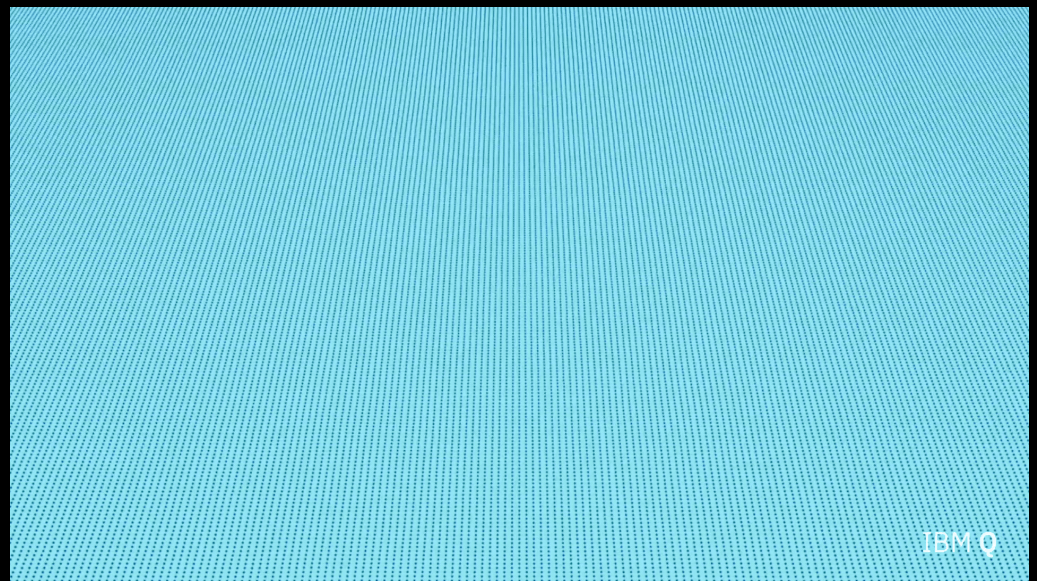
Quantum computing may provide a new path to solve some of the hardest or most memory intensive problems in business and science.

Quantum Superposition



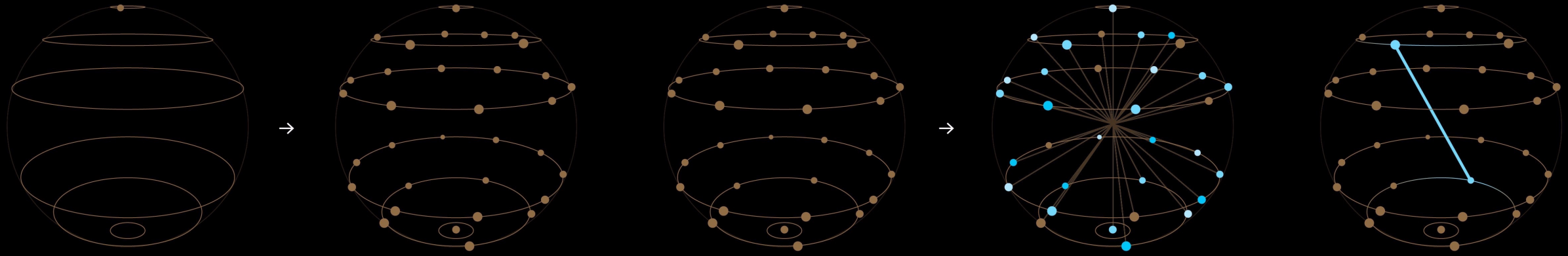
Quantum Entanglement

Quantum Interference



Using a Quantum Algorithm to Tackle Big Problems

A step-by-step guide for how qubits harness nature to find solutions



The Spread

Create an equal superposition of all 2^n states

The Problem

Encode the problem onto the system by applying a phase on all 2^n of the states

The Magic

Interfere all of these states back to a few outcomes containing the solution

IBM Q

Counterfeit Coin Problems

See https://www.youtube.com/watch?v=tE2dZLDJSjA

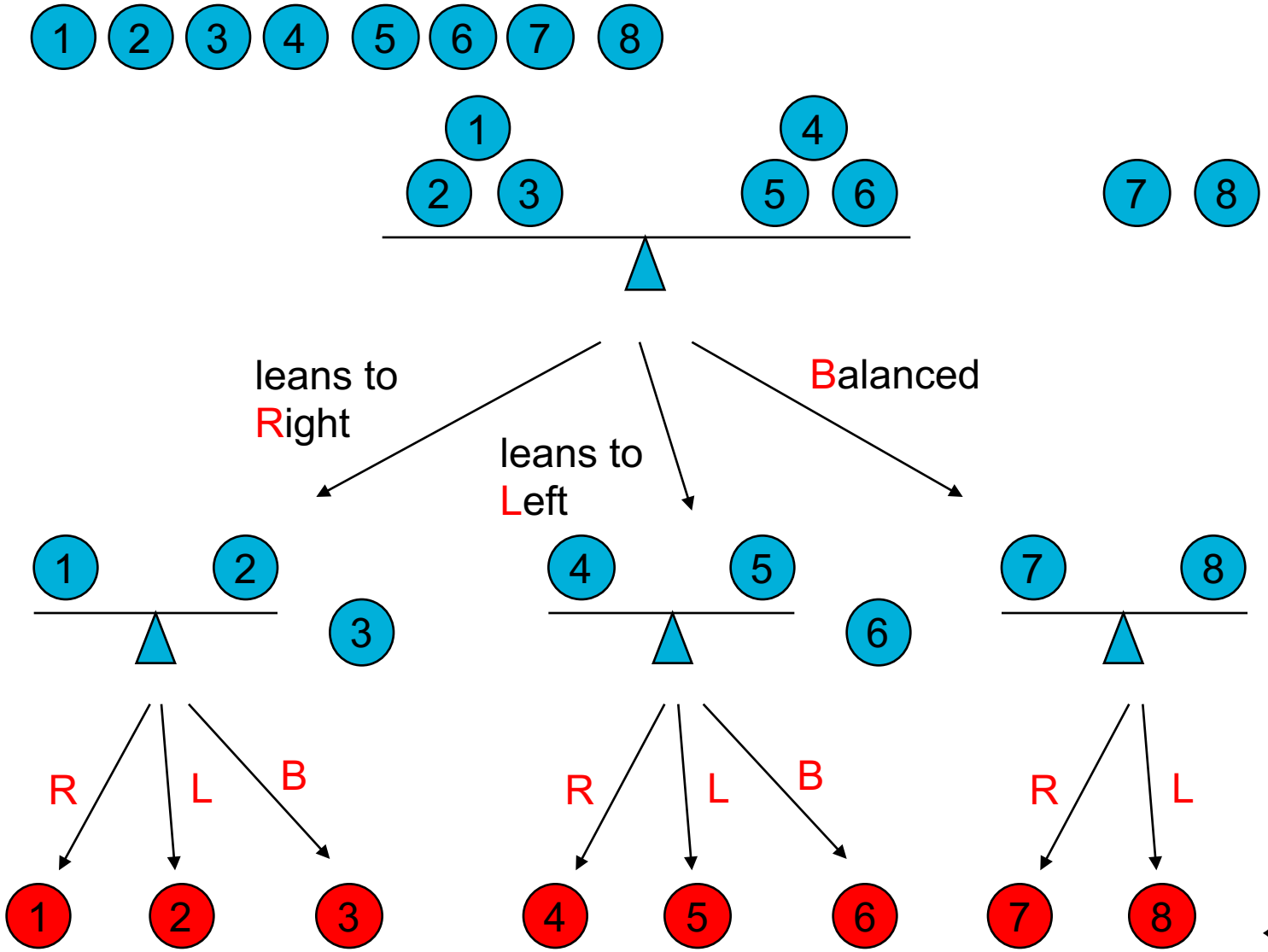
Counterfeit Coin Problem

The counterfeit coin problem is a well-known puzzle.

You have eight similar coins and a beam balance. At most one coin is counterfeit and hence underweight. How can you detect whether there is an underweight coin, and if so, which one, using the balance only twice?

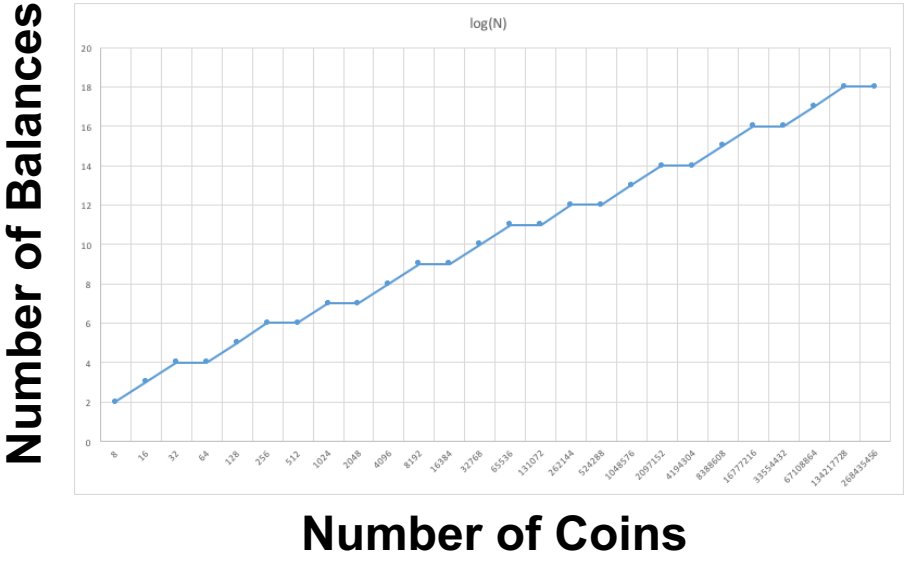
[E.Schell, American Mathematical Monthly 52, p.46, 1945]

Counterfeit Coin Problem



←Answer

Must use more balances as N grows



Quantum Counterfeit Coin Problem

Our goal is to answer the following question:

Q. What is the quantum query complexity of finding all the ***k*** false coins, that is, identifying the input x, from ***N*** total coins?

Results

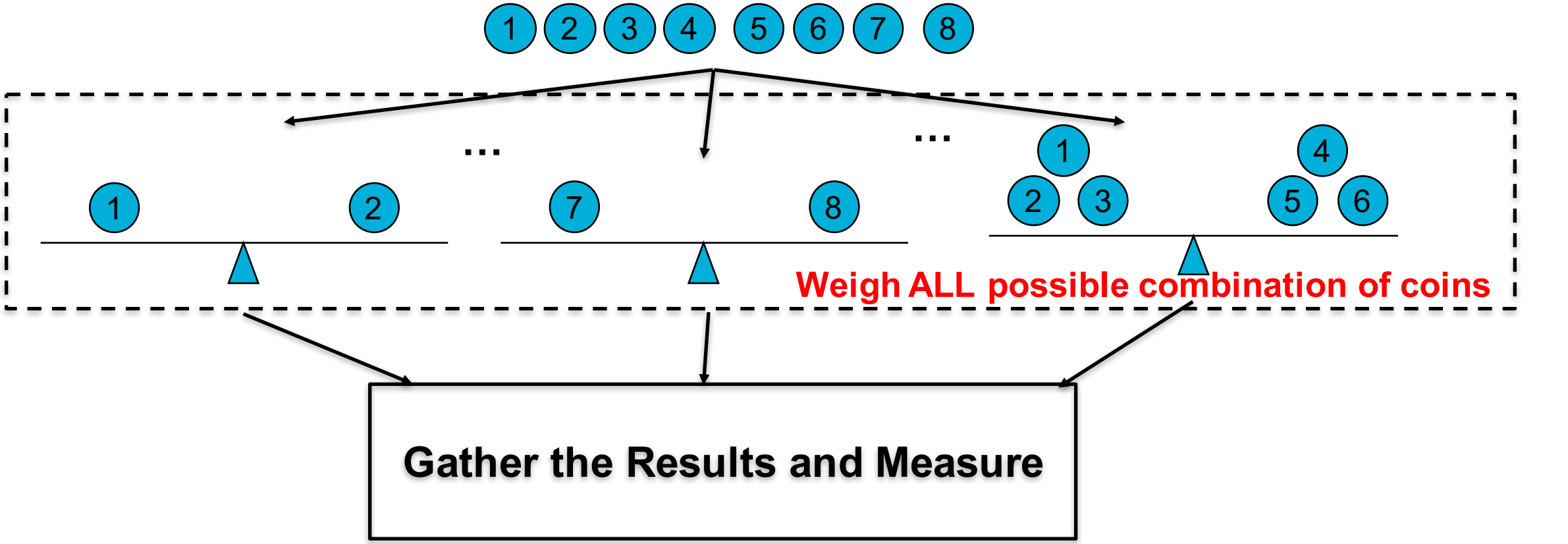
	$k=1$	$k=2$	$k=3$	general
Quantum	1	1	$2 \le k \le 3$	$O(k^{1/4})$
Classical	$\log N$	$\ge 2\log(N/2)$	$\ge 3\log(N/3)$	$\Omega(k \log(N/k))$

quartic speed-up

(Note) So far, there are few natural problems whose quantum speed-up are between quadratic and exponential (ex. cubic [van Dam-Shparlinski 08]).

Quantum Counterfeit Coin Problem

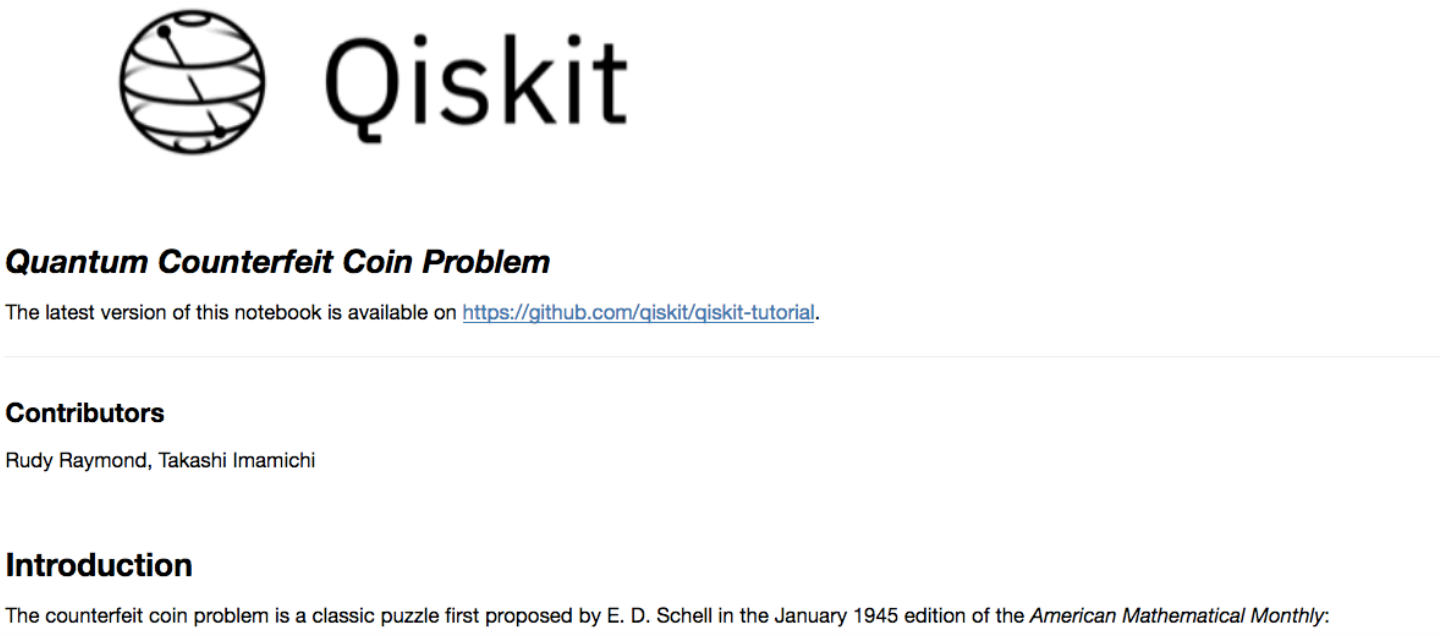
No matter how large N (total coins), we can always find the counterfeit coin with ONE balance



Reference: "Quantum Counterfeit Coin Problem", Iwama et al. ISAAC 2010
Also at "Quantum Algorithm Zoo", https://math.nist.gov/quantum/zoo/

A notebook on Quantum Counterfeit Coin Problem

- See: https://nbviewer.jupyter.org/github/Qiskit/qiskit-tutorial/blob/master/community/games/quantum_counterfeit_coin_problem.ipynb



Qiskit

Quantum Counterfeit Coin Problem

The latest version of this notebook is available on https://github.com/qiskit/qiskit-tutorial.

Contributors

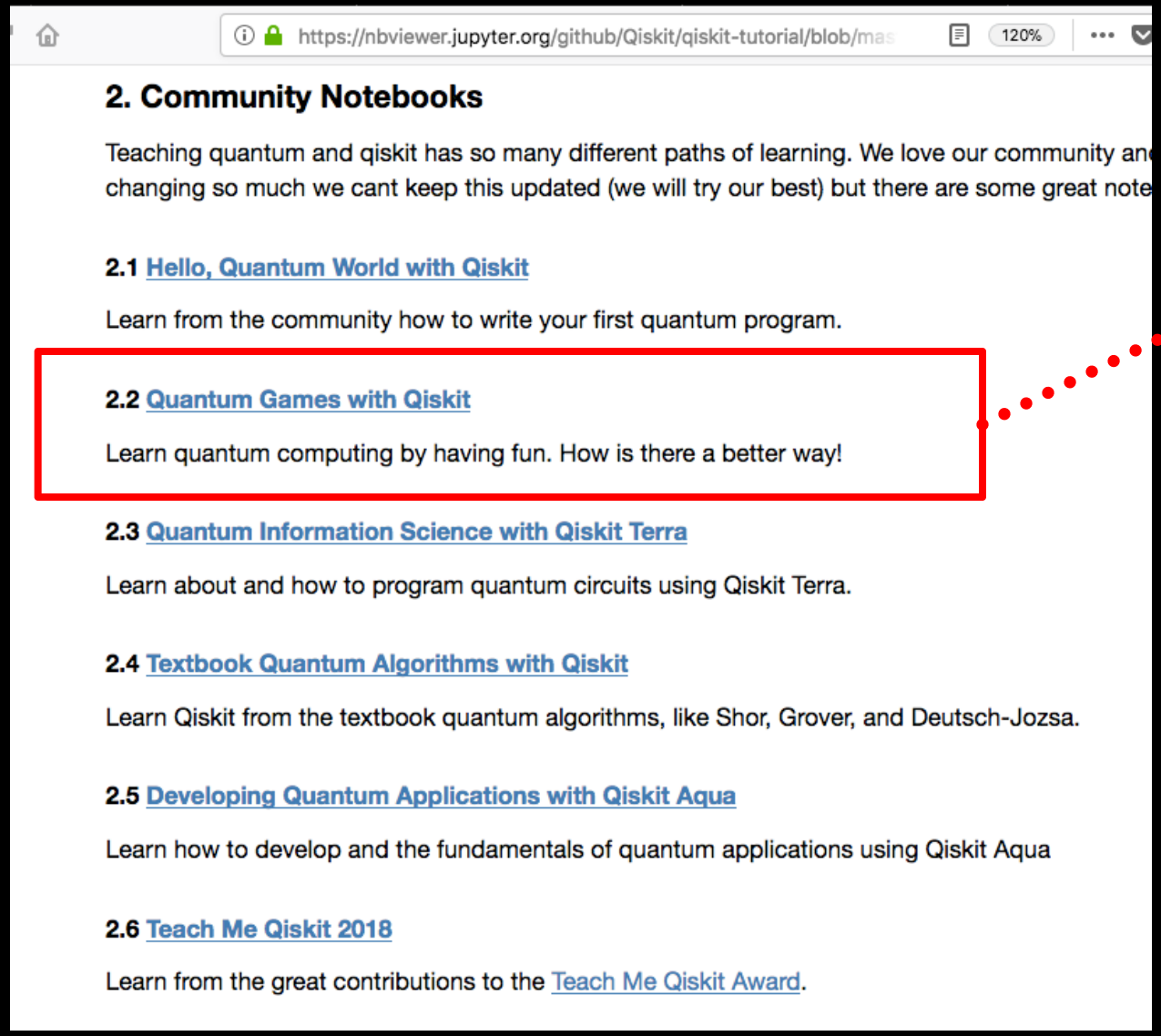
Rudy Raymond, Takashi Imamichi

Introduction

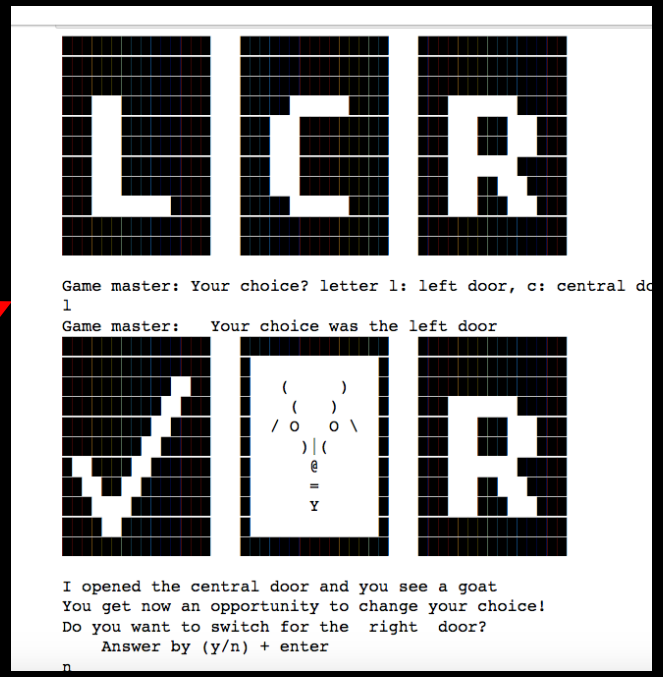
The counterfeit coin problem is a classic puzzle first proposed by E. D. Schell in the January 1945 edition of the *American Mathematical Monthly*:

Creativity using Quantum Computing

https://nbviewer.jupyter.org/github/Qiskit/qiskit-tutorial/blob/master/index.ipynb



Monty-Hall Games with QC



http://helloquantum.mybluemix.net/


QUA
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Thank Q!