

# Quantum Computing

ЧИГРИНА Е.О., ВОРОБЬЕВ Ю.А, КТМО<sub>1-5</sub>

# Contents

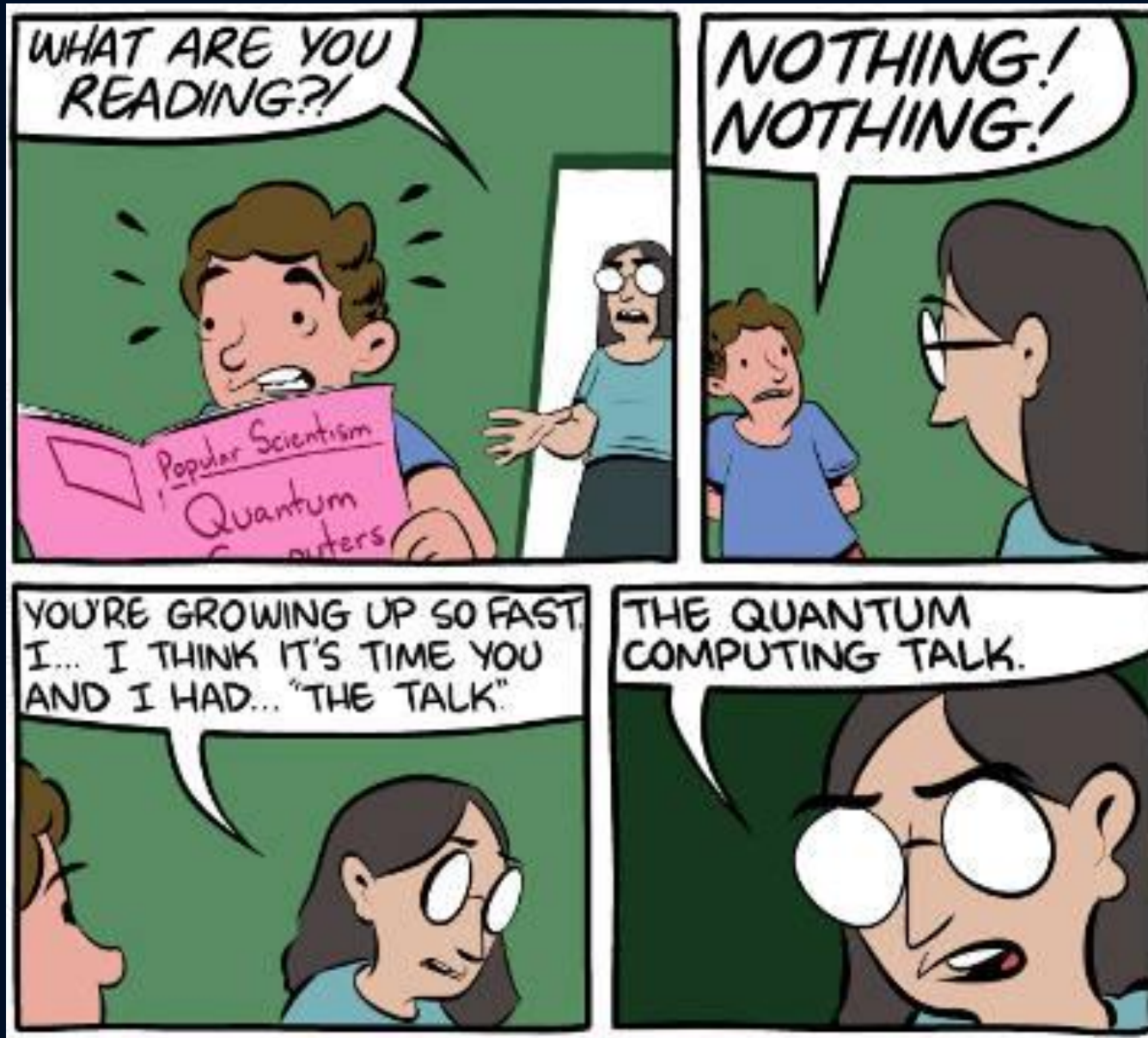
- Glossary
- Quantum Computing in Brief
- Methodology
- State of the Art and Open Issues
- Industry Leaders, Startup
- Bibliography

# Glossary

- **Quantum Computing** is computing using quantum-mechanical phenomena, such as superposition and entanglement.
- **Qubit or Quantum bit** is the basic unit of quantum information—the quantum version of the classical binary bit physically realized with a two-state device.
- **Superposition** is a fundamental principle of quantum mechanics. It states that, much like waves in classical physics, any two (or more) quantum states can be added together ("superposed") and the result will be another valid quantum state;
- **Entanglement** is a physical phenomenon which occurs when pairs or groups of particles are generated, interact, or share spatial proximity in ways such that the quantum state of each particle cannot be described independently of the state of the other(s), even when the particles are separated by a large distance—instead, a quantum state must be described for the system as a whole.



# Quantum Computing in Brief



# Quantum Computing in Brief:

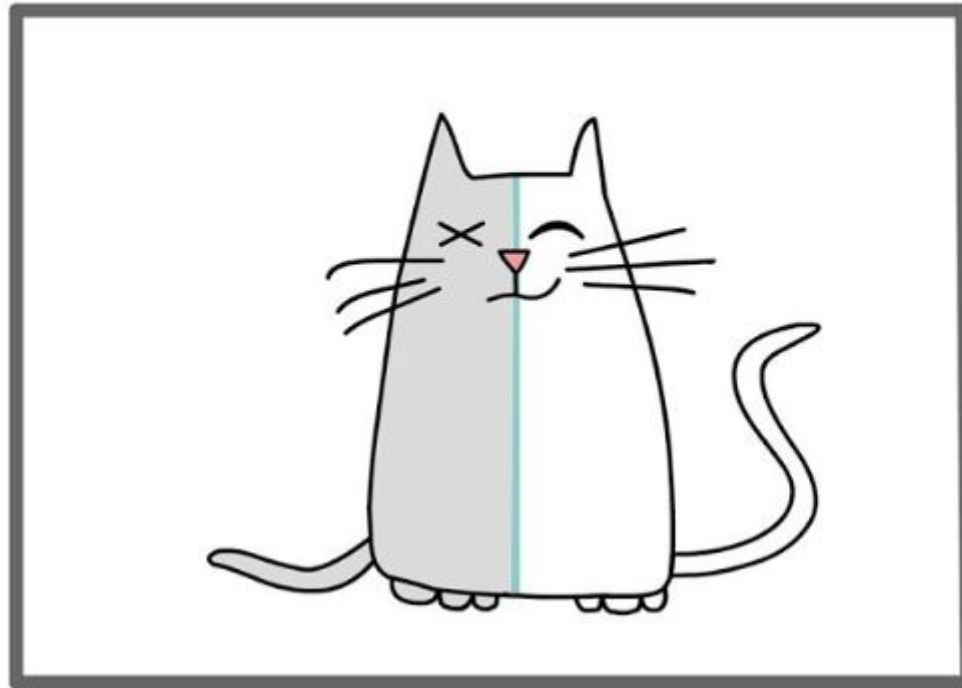
- A quantum system replaces classical bits with quantum qubits
- Qubits follow the superposition principle and can exist as “0” and “1” at the same time
- Using qubits, one could process all possible combinations at the same time

# Quantum Computing in Brief: Quantum Theory

- Energy, like matter, consists of discrete units, rather than solely as a continuous wave.
- Elementary particles of both energy and matter, depending on the conditions, may behave like either particles or waves.
- The movement of elementary particles is inherently random, and, thus, unpredictable.
- The simultaneous measurement of two complementary values, such as the position and momentum of an elementary particle, is inescapably flawed; the more precisely one value is measured, the more flawed will be the measurement of the other value.

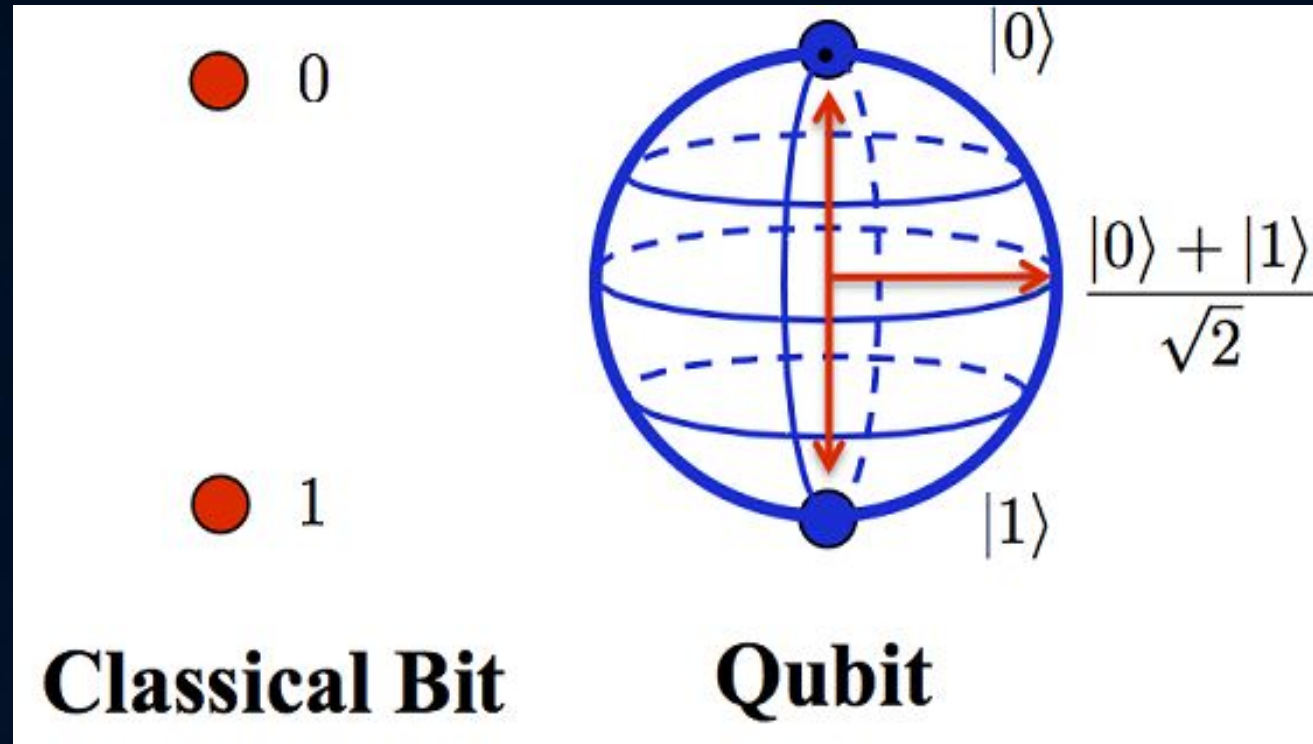
Methodology:  
Developments of Quantum Theory

# Schrödinger's Cat





# Methodology: Superposition





# Methodology:

## Quantum Programming

### Shor's algorithm

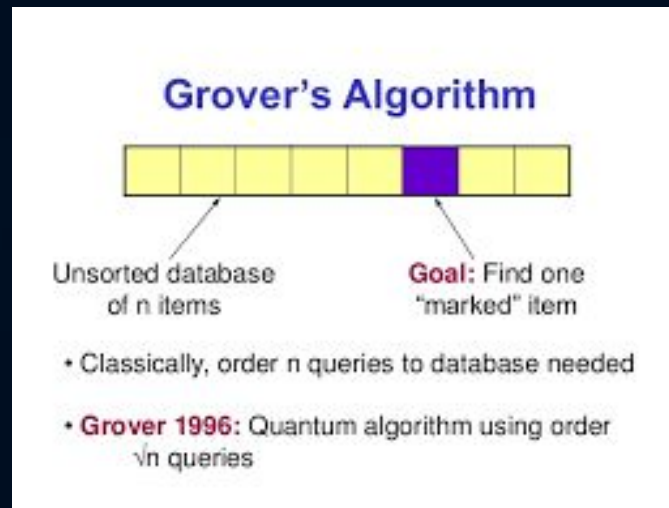
- Shor's algorithm is a quantum algorithm for integer factorization, informally, it solves the following problem: Given an integer  $M$ , find its prime factors.
- On a quantum computer, to factor an integer  $N$ , Shor's algorithm runs in polynomial time (the time taken is polynomial in  $\log N$ , which is the size of the input).

# Methodology:

## Quantum Programming

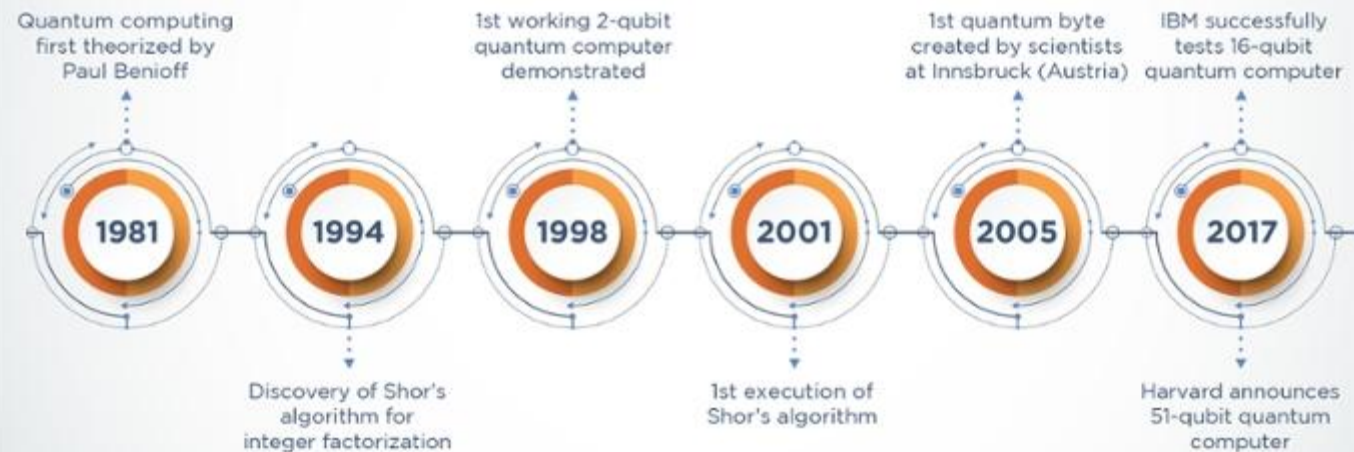
### Grover's algorithm

- Grover's algorithm is a quantum algorithm that finds with high probability the unique input to a black box function that produces a particular output value, using just  $O(\sqrt{N})$  evaluations of the function, where  $N$  is the size of the function's domain



# State of the Art and Open Issue: State of the Art

## QUANTUM COMPUTING TIMELINE



# State of the Art and Open Issue: Open Issue

- Interference
- Error correction
- Output observance



# Industry Leaders, Startups

Name	Score	Pubs	Confs	Grants	Patents	TMs	News	Web
<a href="#">Microsoft</a>	7169.7	63	25	-	46	-	135	-
<a href="#">Massachusetts Institute of Technology</a>	2313.1	159	48	33	-	-	127	-
<a href="#">IBM</a>	2092.8	82	13	5	31	-	126	-
<a href="#">Harvard University</a>	1605.4	165	8	18	3	-	73	-
<a href="#">Google</a>	1313.2	29	6	-	4	-	176	-
<a href="#">University of Oxford</a>	1029.6	184	44	62	-	-	41	-
<a href="#">D-Wave Systems</a>	800.6	16	4	-	36	-	89	8
<a href="#">1Qb Information Technologies</a>	782.5	-	-	-	6	2	-	-
<a href="#">University of Waterloo</a>	619.4	229	61	-	-	-	32	-
<a href="#">National University of Singapore</a>	617.0	214	57	1	-	-	46	-

HOW'S YOUR  
QUANTUM COMPUTER  
PROTOTYPE COMING  
ALONG?

GREAT!



Dilbert.com DilbertCartoonist@gmail.com

THE PROJECT EXISTS  
IN A SIMULTANEOUS  
STATE OF BEING BOTH  
TOTALLY SUCCESSFUL  
AND NOT EVEN  
STARTED.



4-17-12 ©2012 Scott Adams, Inc. /Dist. by Universal Uclick

CAN I  
OBSERVE  
IT?

THAT'S  
A TRICKY  
QUESTION.



# Bibliography

- Patrick J. Coles Quantum Algorithm Implementations for Beginners
- Michael A. Nielsen, Quantum computation and quantum information
- Ashley Montanaro, Quantum algorithms: an overview

THANK FOR ATTENTION!