Exponential Growth

In Quantum Computing

Tough Choice?

Imagine this: one day you're walking along, when suddenly you meet a pancake fairy!

You ask her for pancakes, and she gives you two options:

A million (1,000,000) pancakes right now!

OR

1 pancake today, 2 tomorrow, 4 the next, then 8, … for 30 days

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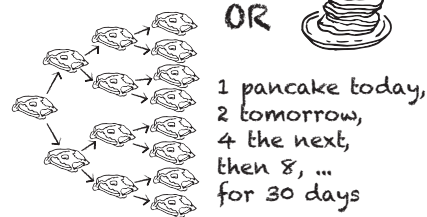
How do you choose?
(in order to maximize pancakes)

Adding up the pancakes from the second option…

$$1 + 2 + 4 + 8 + \cdots + 2^{29} = 2^{30} - 1$$
$$= 1,073,741,823 \text{ pancakes}$$

Wow! That's a lot of pancakes!

Doubling the amount of pancakes each day is a form of **exponential growth**

Superposition is Powerful!

Given n bits, there are 2^n permutations of these bits

000 001 010 011
100 101 110 111

n classical bits can only represent 1 of these permutations at a time

With superposition, n qubits can be a combination of all permutations at once

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Example

8 classical bits:

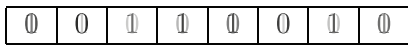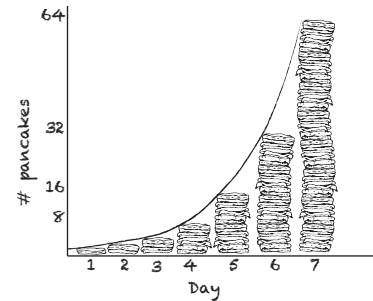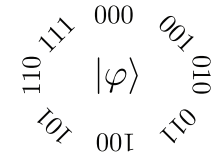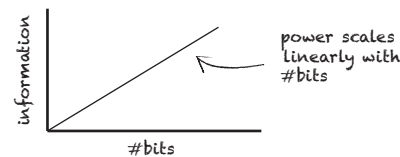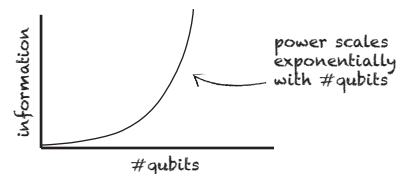| 1	0	0	1	0	0	0	0

8 pieces of information

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8 qubits in superposition:

$2^8 = 256$ possible states in superposition, giving 256 pieces of information

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Adding a qubit

Add a classical bit:

power scales linearly with #bits

8 -> 9 pieces of info

Add a qubit:

power scales exponentially with #qubits

256 -> 512 pieces of info

Caveats

Superposition allows a qubit to hold multiple values at once

$$a\,|00\rangle$$
$$b\,|01\rangle$$
$$c\,|10\rangle \quad \rightarrow \quad |10\rangle$$
$$d\,|11\rangle$$
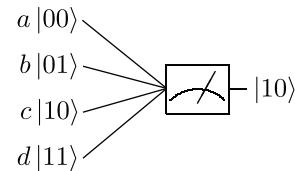
But we can only read out one value, and doing so destroys all the others!

Current qubits are error-prone and can only be used for a short time

…my pancakes
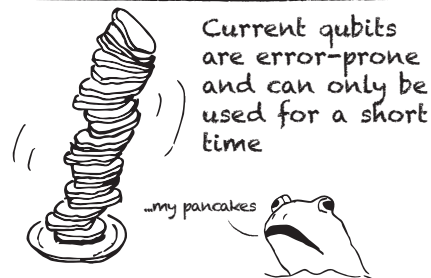
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