🚀 **CHALLENGE COMPLETED** View successful submissions

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Cascadar 200 points

Backstory

Zenda and Reece have determined Doc Trine's cell number in hyperjail. Searching through Trine's notebooks, they find another note, explaining how the hypercube is patrolled by a fearsome quantum warden, which is able to place itself in a superposition and inspect multiple cells at once. To avoid detection and rescue Doc Trine, they need to build a quantum radar!

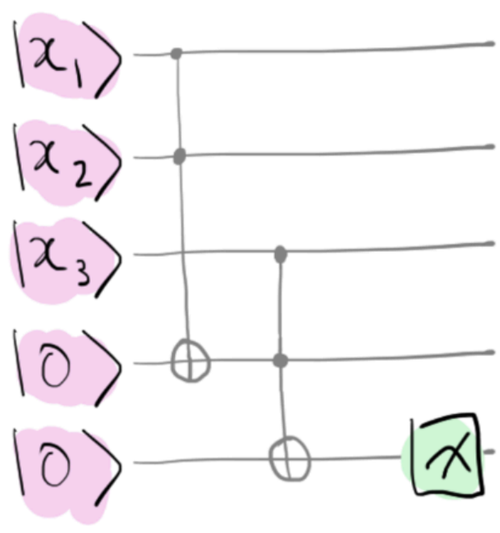
A quantum radar

The quantum guard can place itself in a superposition

$$|\text{guard}\rangle = \sum_x g_x |x\rangle,$$

where $x \in \{0,1\}^5$ ranges over all cell numbers, and g_x are complex-valued amplitudes. Seen in this way, $|g_x|^2$ is the probability that the guard is at position $|x\rangle$. They know that Doc Trine is located in a cell $c = (1,1,0,0,1)$. Ideally, they would like to wait until the guard's attention, captured by the probability $|g_c|^2$, is sufficiently low.

In this challenge, we will look for a way to be able to measure $|g_c|^2$. Unfortunately, there isn't much equipment in the office, and what is there is noisy! But Trine has left a collection of "Toffoli cascades" lying around, circuits made from a string of noisy Toffoli gates. Here is an example for three input qubits $|x_1\rangle|x_2\rangle|x_3\rangle$:



Measuring the last qubit in the computational basis gives $|(x_1 \cdot x_2 \cdot x_3)\rangle$ with probability 1, where $x_1 \cdot x_2 \cdot x_3$ indicates the *product* of classical bits x_1, x_2, and x_3. There is a Toffoli cascade acting on 5 input qubits (and with four auxiliary qubits) that Zenda and Reece can use, as well as some Pauli X gates. All are subject to *depolarizing noise*, such that after each gate, the state on each qubit is replaced with something random with probability λ.

Your task: use noisy Toffoli cascades and noisy-Pauli X gates to build a *quantum radar*, which outputs $|g_c|^2$, the guard's attention on Trine's cell. The guard state will be an input, along with four auxiliary qubits starting in the $|0\rangle$ state.

Challenge code

In the code below, you are given various functions:

- `noisy_PauliX`: which applies the Pauli-X gate and then a layer of depolarizing noise with parameter `lmbda`. (The noise is added for you.)
- `Toffoli_cascade`: a cascade of noisy Toffoli gates (noise parameter `lmbda`) which help compute a product, as in the circuit pictured above, with the input qubits on `in_wires` and auxiliary system `aux_wires`. (The noise is added for you.)
- `cascadar`: which takes a `guard_state (numpy.tensor)` and returns $|g_c|^2$, using noisy equipment with parameter `lmbda`. **You must complete this function**.

Inputs

The noisy quantum radar `cascadar` takes as input the guard state `guard_state (numpy.tensor)`, and a noise parameter `lmbda (float)` controlling the depolarizing noise.

Output

Your `cascadar` function should gives the correct probability $|g_c|^2$ for test cases, including the effects of noise.

If your solution matches the correct one within the given tolerance specified in `check` (in this case it's a `1e-4` relative error tolerance), the output will be `"Correct!"` Otherwise, you will receive a `"Wrong answer"` prompt.