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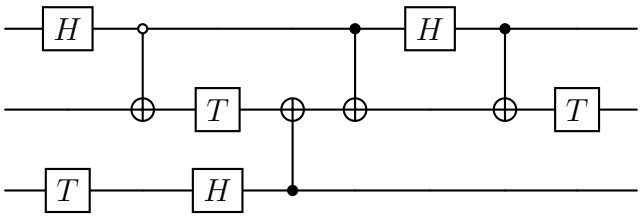
Exercise 5

Task 1. The complexity class **NC** (*Nick's Class*) consists of all problems that can be solved on a PRAM in polylogarithmic time using a polynomial number of processors.

Prove that simulating quantum circuits with non-entangling gates is in **NC**.

Task 2. Let us consider simulating a quantum circuit gate-by-gate using only classical states, but branching when necessary and keeping track of amplitudes and phases.[1]

Let U be the unitray operator defined by the following quantum circuit Q.



(a) Draw a tree of all simulation paths of Q, as described above, starting with $|000\rangle$. Label the edges with corresponding changes in amplitude and/or phase.

(b) Compute $\langle 010|U|000\rangle$ via summation over all relevant paths in the simulation tree. Similarly, compute the probability of measuring the first qubit of $U|000\rangle$ to be $|1\rangle$.

Task 3. Show that **QCMA** $\subseteq$ **QMA** (slide 120). *Hint:* Measure the proof.

[1] The proof showing that **QMA** $\subseteq$ **PSPACE** from the lectures (slides 142–151) is based on this idea.