1.11.6 More time, more memory

Part A

Consider any transition from one state to another. The total number of possible distinguishable states a state can transition to is N. We repeat this for a total of k steps.

Hence, the maximum number of computational paths connecting an input with a specific output is:

$$\Pi^k N = N \times N \ldots \times N = N^k$$

Part B

The execution time and memory requirement grow with k and N.

As shown above, the quantum machine can be configured with N distinguishable states and N^k unique mutually exclusive paths.

In a quantum computational process, each path is associated with a complex amplitude probability z_i, $i \in (0, k)$. z_i represents the amplitude contributed by that path.

Growing N:

- **Time Complexity:** Assuming k is held constant, the time complexity increases polynomially.
- **Space Complexity:** Polynomial for the same reason as time complexity.

Growing k:

- **Time Complexity:** $\mathcal{O}(N^k)$, exponential in k. The number of amplitudes to process is on the order of $\mathcal{O}(N^k)$.
- **Space Complexity:** Exponential in k. The number of amplitudes to store is on the order of $\mathcal{O}(N^k)$, which is exponential in k.