

Image Computation for Quantum Transition Systems

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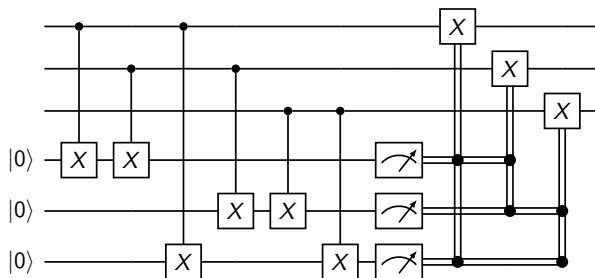
transition system

our method

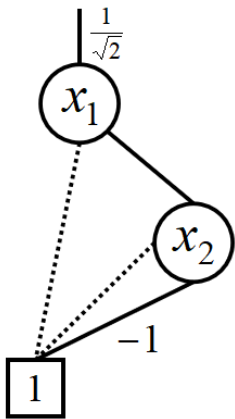
transition system: (S, I, Σ, T)

$$\text{where } \begin{cases} x = x_1, \dots, x_n \\ y = y_1, \dots, y_n \\ \sigma = \sigma_1, \dots, \sigma_m \end{cases}$$

Quantum transition system: (S, S_0, Σ, R)



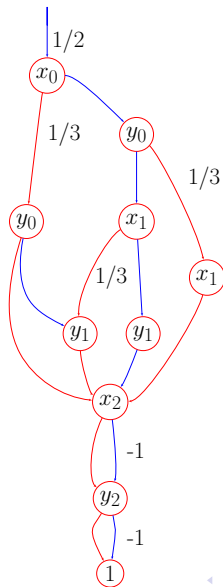
$$\text{CNOT} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$



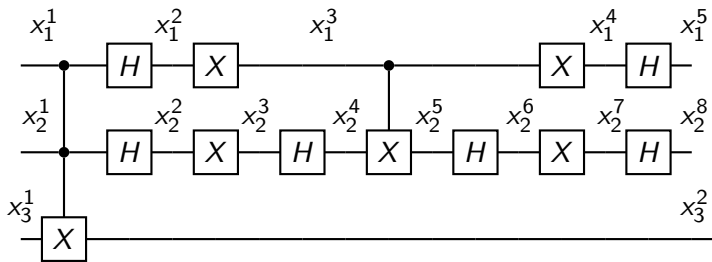
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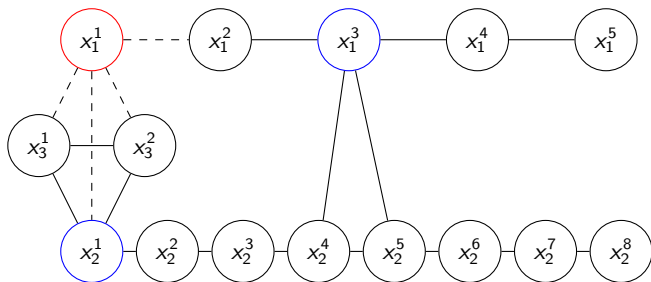
$$\begin{matrix} x_2 = 0 & x_2 = 1 \\ x_1 = 0 & \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{\sqrt{2}} \end{bmatrix} \\ x_1 = 1 & \end{matrix}$$

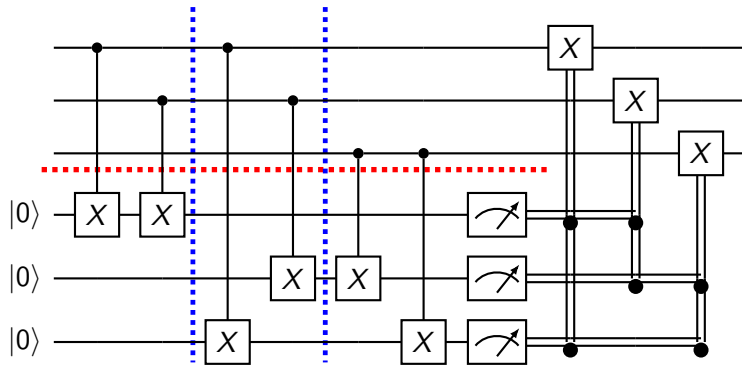
$$P = \frac{1}{6} \begin{bmatrix} 1 & -1 & 1 & -1 & 1 & -1 & 0 & 0 \\ -1 & 1 & -1 & 1 & -1 & 1 & 0 & 0 \\ 1 & -1 & 1 & -1 & 1 & -1 & 0 & 0 \\ -1 & 1 & -1 & 1 & -1 & 1 & 0 & 0 \\ 1 & -1 & 1 & -1 & 1 & -1 & 0 & 0 \\ -1 & 1 & -1 & 1 & -1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 3 & -3 \\ 0 & 0 & 0 & 0 & 0 & 0 & -3 & 3 \end{bmatrix}$$



benchmark	time
Grover 20	~5min
Quantum Fourier Transform 20	~20min
Quantum Random walk 20	~6min
Bernstein-Vazirani 50	~4min
GHZ 500	~3sec







benchmark	basic	addition	contraction
Grover 20	~5min	~4min	~4sec
Quantum Fourier Transform 20	~20min	~11min	<1sec
Quantum Random walk 20	~6min	~4min	~15sec
Bernstein-Vazirani 50	~4min	~4min	~16sec
GHZ 500	~3sec	~1.5sec	~1.7sec

circuit		$k = 0$	$k = 1$	$k = 3$
Grover_40	time	1,510.42	1,519.24	1,495.20
	max #node	589,865	393,423	245,814
QFT_100	time	121.28	118.78	128.31
	max #node	524,369	262,226	131,155

efficient quantum image computation algorithms

contraction partition-based algorithm