Reachability Analysis for Quantum Model Checking using TDD

毕业设计开题报告

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Background

Related work

Work plan

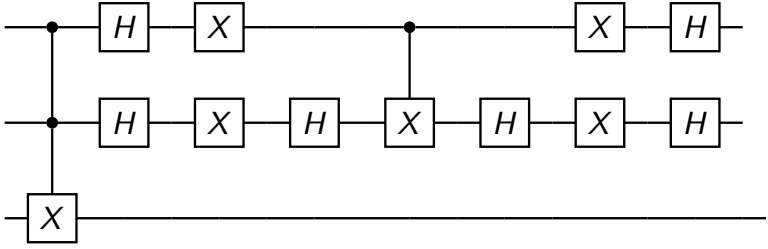


图: Quantum circuit of Grover algorithm

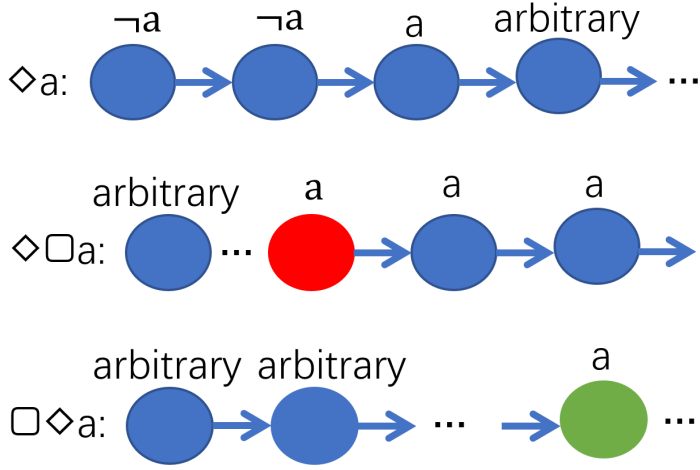
$$H = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}, X = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \tag{1}$$

$$CX = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}, CCX = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

transition system: (S, I, Act, T)

Quantum transition system: $(\mathcal{H}, \mathcal{H}_0, Act, \{U_\alpha, \alpha \in Act\})$

Reachability problem: $\diamondsuit, \diamondsuit\Box, \Box\diamondsuit$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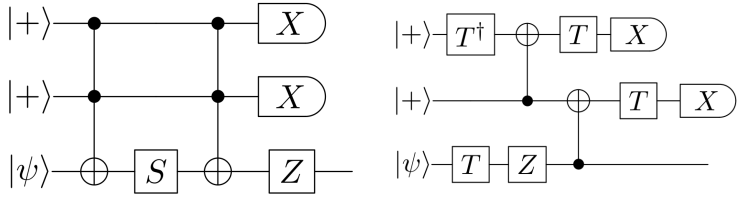
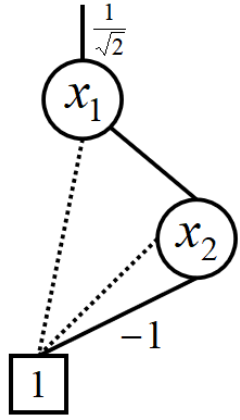


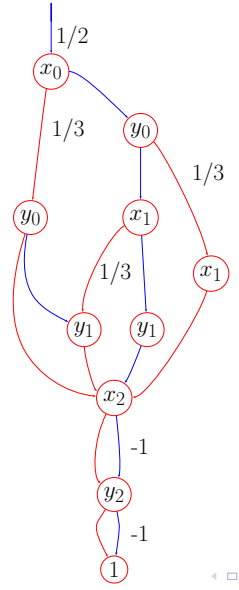
图: Circuit Equivalence Checking



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

图: a TDD example

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



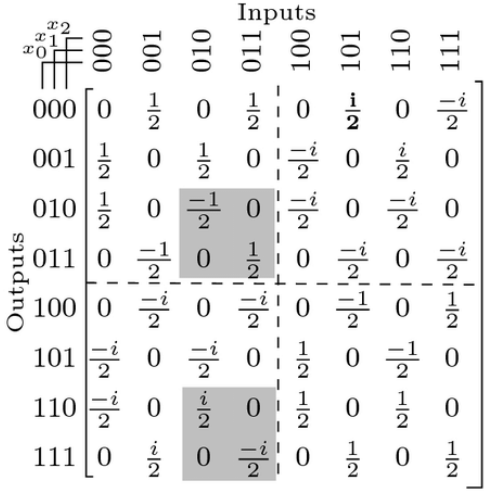
Background

Related work

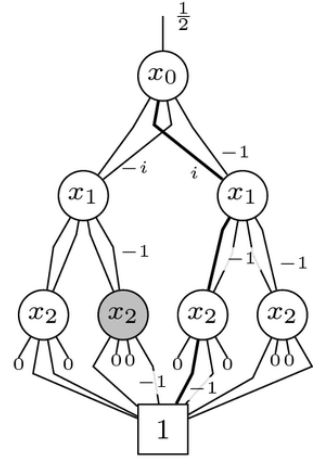
Work plan

QMC,early study on quantum model checking:

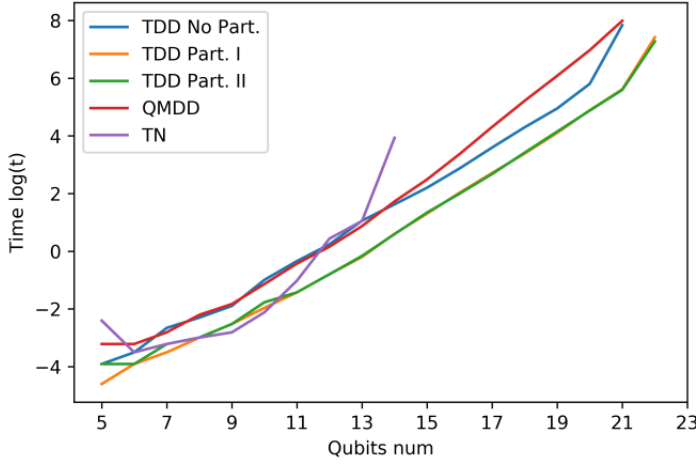
```
init 3; // Initialise 3-qubit system state
int teleportme := 0; /* 0 = |0>, 1 = |1>, 2 =|0>+|1>, 3 =|0>-|1> */
if ((teleportme==1) \/ (teleportme==3)) do { X q0; };
if (teleportme>1) do { had q0; };
had q1; cnot q1 q2;
cnot q0 q1; had q0;
int a,b; a:= meas q0; b := meas q1;
if (b==1) do { X q2; }; if (a==1) do { Z q2; };
```



(a) Matrix



(b) QMDD


TDD No Part.
TDD Part. I
TDD Part. II
QMDD
TN
Time log(t)
Qubits num
8
6
4
2
0
−2
−4
5
7
9
11
13
15
17
19
21
23

Background

Related work

Work plan

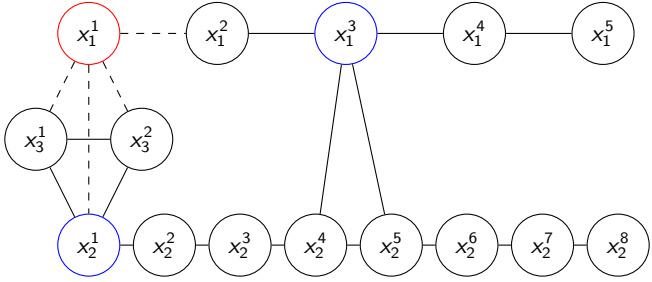


图: addition partition

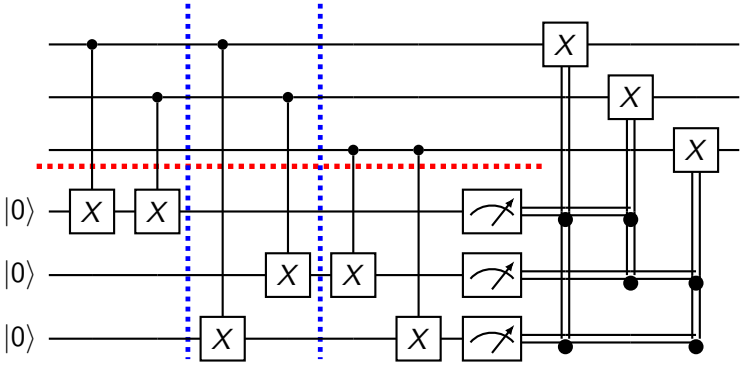


图: contraction partition

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

表: quantum image computation

Reachability space

Reachability problem

Actual problems

Hardware supports

Supports from professor Ying, Phd Hong et al.