A Uniform Method for Quantum Costs Optimization of Reversible Circuits

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Tools and Methods
- MATLAB programming language.
- RevKit-1.0 tools for quantum circuits simulation.
- RevLib: online resource for benchmark circuits.
- C/C++ programming language.
- Implementation of two-qubit gate library.
- Decomposition of MCT-circuits into quantum circuits.
- Implementation of template matching algorithm.

Experimental Results
- Reversible benchmark MCT-circuits provided in RevLib pages as shown in the first column of table 4.
- The total costs reduction in percentage after applying existing templates, reconfigured template (only one) as well as two-qubit operations in last column.
- Significant costs reduction up to 64% by applying template matching algorithm as well as two-qubit operations without using optimum quantum implementation of high ordered Toffoli.

Table 4. Quantum cost reduction using template matching and two-qubit gate library

<table>
<thead>
<tr>
<th>Template</th>
<th>#Qgate</th>
<th>Quantum cost</th>
<th>Total costs reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>not</td>
<td>2</td>
<td>14</td>
<td>0%</td>
</tr>
<tr>
<td>cnot</td>
<td>4</td>
<td>20</td>
<td>0%</td>
</tr>
<tr>
<td>crnot</td>
<td>8</td>
<td>40</td>
<td>0%</td>
</tr>
<tr>
<td>crnot2</td>
<td>16</td>
<td>80</td>
<td>0%</td>
</tr>
<tr>
<td>crnot4</td>
<td>32</td>
<td>160</td>
<td>0%</td>
</tr>
</tbody>
</table>

Conclusion
- Template matching takes full advantage of costs reduction in quantum circuits.
- The best solution can be achieved by reconfigured templates.
- Uniform method of costs optimization in quantum circuits helps to reduce the complexity of finding optimal reversible circuits.

Reference