TECHNOLOGY SCIENCE JOURNAL FOR TEENS

# Comparing Quantum Simulators

**WORKSHEET**

The table below shows the data from five different simulators attempting four simulations of quantum computations. The fifth simulator was our approach, using decision diagrams.

Each simulated computation was attempted with a different number of qubits, and we recorded the time in seconds and the memory in MB the computation would require. Some simulators were unable to simulate computations due to missing features, so we recorded "n.a." for "not applicable." In other cases, there was not enough memory to store the matrices/vectors and the computers couldn't complete the simulations, so we recorded "MO" for "Memory Out."

1. Which approach is the fastest overall and uses the least memory for the different computations?
2. What effect does the number of qubits have on the required time and the required memory?

| Computation | Number of qubits | Simulator 1 | | Simulator 2 | | Simulator 3 | | Simulator 4 | | Our approach | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time (s) | Memory (MB) | Time (s) | Memory (MB) | Time (s) | Memory (MB) | Time (s) | Memory (MB) | Time (s) | Memory (MB) |
| **Comp. 1** | 22 | 4 | 193 | <1 | 200 | 1 | 152 | <1 | 15 | <1 | 48 |
| | 23 | 4 | 248 | <1 | 397 | <1 | 248 | <1 | 15 | <1 | 48 |
| | 24 | n.a. | -- | 2 | 790 | <1 | 445 | <1 | 15 | <1 | 48 |
| | 26 | n.a. | -- | 7 | 3150 | 3 | 1625 | <1 | 15 | <1 | 48 |
| | 28 | n.a. | -- | 31 | 12587 | 5 | 6343 | <1 | 15 | <1 | 48 |
| | 29 | n.a. | -- | 63 | 25170 | 9 | 12635 | <1 | 15 | <1 | 48 |
| | 30 | n.a. | -- | MO | -- | 18 | 25218 | <1 | 15 | <1 | 48 |
| | 31 | n.a. | -- | MO | -- | MO | -- | <1 | 15 | <1 | 48 |
| | 100 | n.a. | -- | MO | -- | MO | -- | <1 | 16 | <1 | 49 |
| **Comp. 2** | 18 | 3 | 193 | <1 | 17 | <1 | 58 | 24 | 193 | <1 | 48 |
| | 20 | 4 | 189 | 2 | 53 | <1 | 76 | 2263 | 1210 | <1 | 49 |
| | 21 | 7 | 193 | 4 | 103 | <1 | 101 | 10208 | 2511 | <1 | 49 |
| | 22 | 11 | 131 | 8 | 201 | 1 | 150 | MO | -- | <1 | 49 |
| | 23 | 22 | 312 | 15 | 398 | 2 | 250 | MO | -- | <1 | 49 |
| | 24 | n.a. | -- | 32 | 791 | 3 | 445 | MO | -- | <1 | 49 |
| | 26 | n.a. | -- | 139 | 3150 | 12.8 | 1625 | MO | -- | <1 | 49 |
| | 29 | n.a. | -- | 1270 | 25170 | 109 | 12639 | MO | -- | <1 | 50 |
| | 30 | n.a. | -- | MO | -- | 234 | 25217 | MO | -- | <1 | 50 |
| | 31 | n.a. | -- | MO | -- | MO | -- | MO | -- | <1 | 51 |
| | 64 | n.a. | -- | MO | -- | MO | -- | MO | -- | <1 | 68 |

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| Computation | Number of qubits | Simulator 1 | | Simulator 2 | | Simulator 3 | | Simulator 4 | | Our approach | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time (s) | Memory (MB) | Time (s) | Memory (MB) | Time (s) | Memory (MB) | Time (s) | Memory (MB) | Time (s) | Memory (MB) |
| **Comp. 3** | 16 | 98 | 195 | 56 | 57 | 7 | 52 | 7 | 16 | <1 | 51 |
| | 18 | 770 | 193 | 583 | 144 | 16 | 58 | 24 | 17 | <1 | 51 |
| | 20 | 8495 | 198 | 6395 | 383 | 78 | 77 | 86 | 19 | <1 | 51 |
| | 21 | >18000 | -- | >18000 | -- | 229 | 101 | 168 | 21 | 1 | 51 |
| | 24 | n.a. | -- | >18000 | -- | 5362 | 447 | 1272 | 32 | 3 | 51 |
| | 25 | n.a. | -- | >18000 | -- | 15765 | 844 | 2598 | 41 | 6 | 51 |
| | 26 | n.a. | -- | >18000 | -- | >18000 | -- | 5077 | 53 | 8 | 51 |
| | 27 | n.a. | -- | >18000 | -- | >18000 | -- | >18000 | -- | 15 | 51 |
| | 30 | n.a. | -- | n.a | -- | >18000 | -- | >18000 | -- | 37 | 51 |
| | 40 | n.a. | -- | n.a | -- | MO | -- | >18000 | -- | 1240 | 52 |
| | | | | | | | | | | | |
| **Comp. 4** | 13 | 77 | 66 | n.a. | -- | <1 | 48 | 1665 | 92 | <1 | 53 |
| | 15 | 299 | 63 | n.a. | -- | 9 | 51 | 16236 | 365 | <1 | 55 |
| | 17 | 344 | 129 | n.a. | -- | 19 | 55 | >18000 | -- | <1 | 58 |
| | 19 | 1233 | 85 | n.a. | -- | 47 | 71 | >18000 | -- | 1 | 61 |
| | 21 | 7888 | 147 | n.a. | -- | 187 | 116 | >18000 | -- | 11 | 65 |
| | 23 | >18000 | -- | n.a. | -- | 948 | 284 | >18000 | -- | 3 | 67 |
| | 25 | n.a. | -- | n.a. | -- | 4827 | 861 | >18000 | -- | 18 | 75 |
| | 27 | n.a. | -- | n.a. | -- | >18000 | -- | >18000 | -- | 75 | 83 |
| | 31 | n.a. | -- | n.a. | -- | MO | -- | >18000 | -- | 45 | 98 |
| | 33 | n.a. | -- | n.a. | -- | MO | -- | >18000 | -- | 1020 | 156 |
| | 37 | n.a. | -- | n.a. | -- | MO | -- | >18000 | -- | 5586 | 260 |