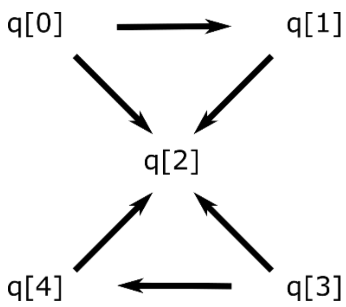
Two-Qubit Gates

A universal gate set includes two-qubit gates. A commonly used two-qubit gate is the controlled-NOT operation or CNOT gate. Independent of which qubit is used as the control qubit and which as the target qubit, the CNOT gate will always apply an X-gate onto the target qubit if the control qubit is in the $|1\rangle$state. When the first qubit is defined as control and the second as target, the matrix form of the CNOT is given by

$$CNOT = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}. \tag{1}$$

You must note that not all combinations of control and target qubits are allowed in the IBM QE. The combinations that you can use are determined by the topology of the IBM Q experience backend.

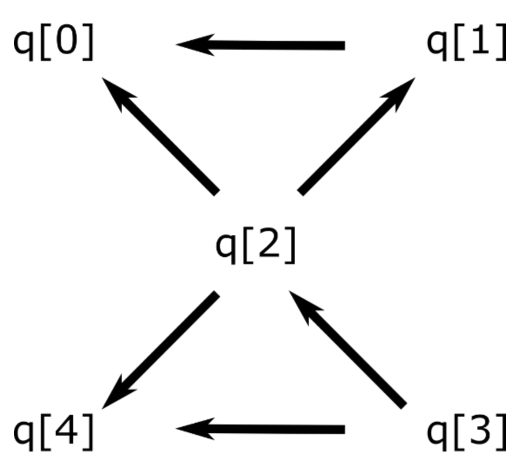
The first backend that we will show is called ibmqx2. The figure below shows its topology.



The following table shows all the allowed combinations for applying a CNOT-gate in QASM using the ibmqx2 backend.

Control qubit	Target qubit	QASM line
q[0]	q[1]	cx q[0],q[1]
q[0]	q[2]	cx q[0],q[2]
q[1]	q[2]	cx q[1],q[2]
q[3]	q[2]	cx q[3],q[2]
q[3]	q[4]	cx q[3],q[4]
q[4]	q[2]	cx q[4],q[2]

The second backend that we will show is called [ibmqx4](). The figure below shows its topology.



The following table shows all the allowed combinations for applying a CNOT-gate in QASM using the ibmqx4 backend.

Control qubit	Target qubit	QASM line
q[1]	q[0]	cx q[1],q[0]
q[2]	q[1]	cx q[2],q[1]
q[2]	q[0]	cx q[2],q[0]
q[2]	q[4]	cx q[2],q[4]
q[3]	q[2]	cx q[3],q[2]
q[3]	q[4]	cx q[3],q[4]