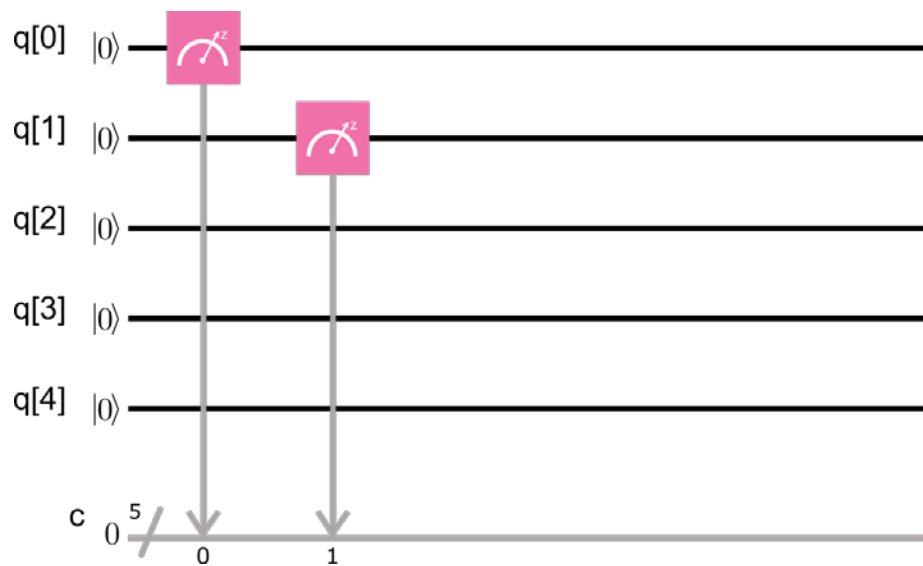


Measurement: Part 2

To better understand how the measurement results are stored in the classical register, let's consider the quantum circuit below



The QASM code that generates this circuit is

```
1 include "qelib1.inc";
2 qreg q[5];
3 creg c[5];
4 measure q[0] -> c[0];
5 measure q[1] -> c[1];
```

Similar to the previous example, the analytical probabilities of projecting qubits $q[0]$ and $q[1]$ onto states $|0\rangle$ and $|1\rangle$ are respectively given by $p(q[0],|0\rangle)=|\langle 0|0\rangle|^2=1$, $p(q[0],|1\rangle)=|\langle 0|1\rangle|^2=0$, and $p(q[1],|0\rangle)=|\langle 0|0\rangle|^2=1$, $p(q[1],|1\rangle)=|\langle 0|1\rangle|^2=0$.

The following figure shows the result of simulating the previous code with 10 shots. Qubits $q[0]$ and $q[1]$ were projected 10 times into state $|0\rangle|0\rangle$. **Note that the label in the left column is "00", this is because two qubits are being measured.**

| c[5] | n |
|------|----|
| 00 | 10 |

The figure below shows the result of running the previous code in a real quantum computer 1024 times. Since the qubit $q[0]$ measurement was stored in $c[0]$, and $q[1]$ in $c[1]$, the labels are given in the order $c[1]c[0]$. The number $n=1014$ at the right of label "00" indicates that qubits $q[0]$ and $q[1]$ were projected onto state $|00\rangle$ 1014 times. The number $n=1$ at the right of label "01" indicates that qubits $q[0]$ and $q[1]$ were projected onto state $|01\rangle$ 1 time. The number $n=9$ at the right of label "10" indicates that qubits $q[0]$ and $q[1]$ were projected onto state $|10\rangle$ 9 times. **Note that there is no label "11"; this is because the qubits were never projected on to state $|11\rangle$.**

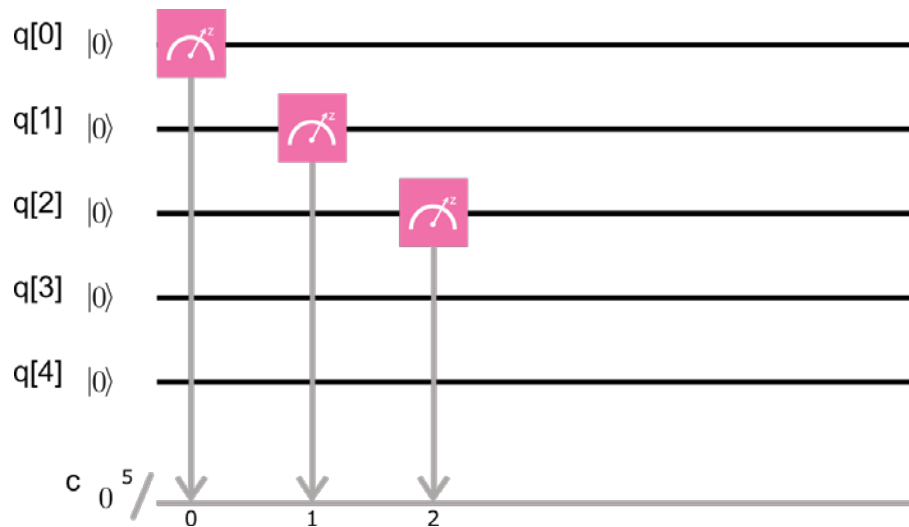
| | |
|------|------|
| c[5] | n |
| 00 | 1014 |
| 01 | 1 |
| 10 | 9 |

The following table shows a summary of the previous results. You can see that the measurement results are in general -- but not perfect -- agreement with the analytical probabilities.

Table 1

| Analytical Probabilities | Quantum state $ q[0]q[1]\rangle$ | Result Label $c[1]c[0]$ | Projection Frequency n |
|--------------------------|-------------------------------------|----------------------------|---------------------------|
| 1 | $ 00\rangle$ | 00 | 1014 |
| 0 | $ 01\rangle$ | 10 | 9 |
| 0 | $ 10\rangle$ | 01 | 1 |
| 0 | $ 11\rangle$ | 11 | 0 |

To understand how the labeling of the results works can be complicated, so let's analyze the following example



The code that generates this quantum circuit is

```
1 include "qelib1.inc";
2 qreg q[5];
3 creg c[5];
4 measure q[0] -> c[0];
5 measure q[1] -> c[1];
6 measure q[2] -> c[2];
```

Since the $q[0]$, $q[1]$ and $q[2]$ measurements are stored in $c[0]$, $c[1]$ and $c[2]$ respectively, the projection results will be stored as in Table 2. If instead the measurements are stored in the following way,

```
1 include "qelib1.inc";
2 qreg q[5];
3 creg c[5];
4 measure q[0] -> c[2];
5 measure q[1] -> c[1];
6 measure q[2] -> c[0];
```

then the projection results will be stored as shown in Table 3

Table 2: $q[0] \rightarrow c[0]$; $q[1] \rightarrow c[1]$; $q[2] \rightarrow c[2]$;

| Label $c[2]c[1]c[0]$ | Quantum state $ q[0]q[1]q[2]\rangle$ |
|-------------------------|---|
| 000 | $ 000\rangle$ |
| 001 | $ 100\rangle$ |
| 010 | $ 010\rangle$ |
| 011 | $ 110\rangle$ |
| 100 | $ 001\rangle$ |
| 101 | $ 101\rangle$ |
| 110 | $ 011\rangle$ |
| 111 | $ 111\rangle$ |

Table 3: $q[0] \rightarrow c[2]$; $q[1] \rightarrow c[1]$; $q[2] \rightarrow c[0]$;

| Label $c[2]c[1]c[0]$ | Quantum state $ q[0]q[1]q[2]\rangle$ |
|-------------------------|---|
| 000 | $ 000\rangle$ |
| 100 | $ 100\rangle$ |
| 010 | $ 010\rangle$ |
| 110 | $ 110\rangle$ |
| 001 | $ 001\rangle$ |
| 101 | $ 101\rangle$ |
| 011 | $ 011\rangle$ |
| 111 | $ 111\rangle$ |