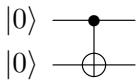
CNOT Interpretation, Superposition, Quantum Parallelism and Quantum Entanglement

January 26, 2016

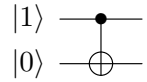
Invariant Effect




```
>> u_propagate(tensor(state('0'),state('0')),helper.ACNOT)

ans = +1 |00>
```

Swapping Effect

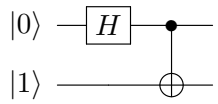


$$CNOT = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix} = \begin{pmatrix} I & 0 \\ 0 & X \end{pmatrix} = \begin{pmatrix} I & 0 \\ 0 & NOT \end{pmatrix}$$

```
>> u_propagate(tensor(state('1'),state('0')),helper.ACNOT)

ans = +1 |11>
```

Control Qubit with Superposition

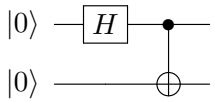


$$H|0\rangle \equiv \frac{1}{\sqrt{2}}\begin{pmatrix}1 & 1\\ 1 & -1\end{pmatrix}\begin{pmatrix}1\\ 0\end{pmatrix} = \frac{|0\rangle + |1\rangle}{\sqrt{2}}$$

```
>> u_propagate(tensor(u_propagate(state('0'),helper.H),state('1')),helper.ACNOT)

ans = +0.707107 |01> +0.707107 |10>
```

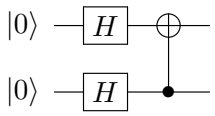
Control Qubit with Superposition




```
>> u_propagate(tensor(u_propagate(state('0'),helper.H),state('0')),helper.ACNOT)

ans = +0.707107 |00> +0.707107 |11>
```

Control and Target Qubit with Superposition



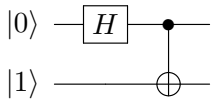

```
>> u_propagate(
   tensor(
      u_propagate(state('0'),helper.H),
      u_propagate(state('0'),helper.H)),
   helper.ACNOT)

ans = +0.5 |00> +0.5 |01> +0.5 |10> +0.5 |11>
```

Quantum Parallelism

1. Output quantum state contains 2^n evaluations, where n is the size.
2. Result of measurement is (only) one of the 2^n evaluations.

Intro to Quantum Entanglement




```
>> r=u_propagate(tensor(u_propagate(state('0'),helper.H),state('1')),helper.ACNOT)

r = +0.707107 |01> +0.707107 |10>

>> [~,b,s]=measure(r,1)

b = 2

s = +1 |10>

>> [~,b,t]=measure(s,2)

b = 1

t = +1 |10>
```

A different run...

```
>> [~,b,s]=measure(r,1)

b = 1

s = +1 |01>

>> [~,b,t]=measure(s,2)

b = 2

t = +1 |01>
```