ENDIANNESS

In computing, **endianness** is the order or sequence of bytes of a word of digital data in computer memory. Endianness is primarily expressed as **big-endian** (**BE**) or **little-endian** (**LE**). A big-endian system stores the most significant byte of a word at the smallest memory address and the least significant byte at the largest. A little-endian system, in contrast, stores the least-significant byte at the smallest address.

Least significant bit and most significant bit:

In computing, the terms "least significant bit" (LSB) and "most significant bit" (MSB) are used to describe the position and significance of individual bits within a binary representation of a number.

In a binary number, each digit is called a bit, and it can have one of two values: 0 or 1. The position of a bit determines its significance in the number's value.

The LSB refers to the bit that occupies the rightmost position or the lowest bit index. It has the least value in the binary representation. For example, in the 8-bit binary number 11001010, the rightmost bit (bit index 0) is the LSB.

The MSB, on the other hand, refers to the bit that occupies the leftmost position or the highest bit index. It has the highest value in the binary representation. Using the same example of the 8-bit binary number 11001010, the leftmost bit (bit index 7) is the MSB.

<infographics explaining MSB and LSB>

ENDIANNESS IN QUANTUM COMPUTING

In quantum computing, endianness refers to the ordering of qubits within a quantum register. Since qubits are the fundamental units of information in a quantum computer, their arrangement can impact how quantum operations and measurements are performed.

The state of a qubit can be described as a linear combination of two basis states, conventionally denoted as |0〉 and |1〉. However, quantum computers typically have multiple qubits, and the ordering of these qubits can vary.

The two common qubit ordering schemes in quantum computing:

Big Endian Ordering: In this scheme, the most significant qubit is placed at the rightmost position(smallest memory address), similar to big endian byte ordering. The least significant qubit is placed at the leftmost position. The qubit arrangement follows the convention used in classical computing systems. For example, if you have a 3-qubit system, the qubits would be ordered as **|qubit0-qubit1-qubit2**〉.

Little Endian Ordering: In contrast to big endian, little endian ordering places the least significant qubit at the rightmost position(smallest memory location) , while the most significant qubit is placed at the leftmost position. This ordering is often preferred in some quantum algorithms and implementations. Using the same example of a 3-qubit system, the qubits would be ordered as **|qubit2-qubit1-qubit0**〉.

The choice of qubit ordering can have implications for designing and implementing quantum algorithms. It affects how qubit operations are applied, how quantum gates are constructed, and how measurements are interpreted.

It's important to note that the choice of qubit ordering in quantum computing is **not** as universally standardized as byte ordering in classical computing. Different quantum computing platforms and programming frameworks may adopt different conventions.

Note that **IBM- Qiskit** uses little endian ordering as its standard qubit ordering. Throughout our tutorials we will use **Qiskit little endian qubit ordering**.

<need an infographic picture showing Qiskit little endian ordering>