As a result, quantum computers (if built) may perform certain tasks much better than classical ones. At first, Deutsch (1985) built a theoretical model of a general-purpose quantum computer and demonstrated that quantum computers theoretically allow massive parallelism in computations. The idea was in using a quantum superposition of the pure states $|x\rangle$ as the replacement of the union of a quantity of classical registers, each in one of the initial states $|x\rangle$. In this context, parallel mappings of register states are realized by unitary operators of quantum physics. There were other achievements in this area, but what really boosted the subject was the result of Shor (1994) that one of the notoriously difficult and practically relevant classical computation problems, namely, the factoring of large numbers, could be speeded up so as to do it rapidly on a quantum computer. This is achieved by an efficient use of highly entangled states to do a massively parallel computation. The results of the computation are then organized in interference of qubit patterns. With Shor's breakthrough, quantum computing transformed from a pure academic discipline into a national and world interest. In this context, exceptionally powerful algorithms were found in three areas: searching a database, abelian group theory, and simulating physical systems (cf. (Freedman, et al, 2002)).

The most attractive candidates for quantum information processors currently come from the area of atomic physics and quantum optics. Here, individual atoms and photons are manipulated in a controlled environment with well-understood couplings, offering environmental isolation that is unsurpassed in other physical systems.

The main hardware requirements for quantum information processors are:

1. The quantum system (that is, a collection of qubits) must be initialized in a well-defined state.
2. Arbitrary unitary operators must be available and controlled to launch the initial state to an arbitrary entangled state.
3. Measurements of the qubits must be performed with high quantum efficiency.

Quantum information theory has many potential applications (quantum computing, quantum cryptography, quantum teleportation)