Quantum Computer Essay, Research Paper

A Quantum Computer… a future technology

By the strange laws of quantum mechanics, Folger, a senior editor at Discover, notes, an electron, proton, or other subatomic particle is “in more than one place at a time,” because individual particles behave like waves, these different places are different states that an atom can exist in simultaneously. Ten years ago, Folger writes, David Deutsch, a physicist at Oxford University, argued that it may be possible to build an extremely

powerful computer based on this peculiar reality. In 1994, Peter Shor, a mathematician at AT&T Bell Laboratories in New Jersey, proved that, in theory at least, a full-blown quantum computer could factor even the largest numbers in seconds–an accomplishment impossible for even the fastest conventional computer.

An outbreak of theories and discussions of the possiblity of buildig a quantum computer now permeates itself thoughtout the quantum fields of technology and research. It’s roots can be traced back to 1981, when Richard Feynman noted that physicists always seem to run into computational problems when they try to simulate a system in which quantum mechanics would take place. The caluclations involving the behavior of atoms, electrons, or photons, require an immense amount of time on today’s computers. In 1985 in Oxford England the first description of how a quantum computer might work surfaced with David Deutsch’s theories. The new device would not only be able to surpass today’s computers in speed, but also could perform some logical operations that conventional ones couldn’t.

This reasearch began looking into actually constructing a device and with the go ahead and additional funding of AT&T Bell Laboratories in Murray Hill, New Jersey a new member of the team was added. Peter Shor made the discovery that quantum computation can greatly speed factoring of whole numbers. It’s more than just a step in micro-computing technology, it could offer insights into real world applications such as cryptography. “There is a hope at the end of the tunnel that quantum computers may one day become a reality,” says Gilles Brassard of University of Montreal.

Quantum Mechanics give an unexpected clarity in the description of the behavior of atoms, electrons, and photons on the microscopic levels. Although this information isn’t applicable in everday household uses it does certainly apply to every interaction of matter that we can see, the real benefits of this knowledge are just beginning to show themselves. In our computers, circut boards are designed so that a 1 or a 0 is represented by differering amounts of electriciy, the outcome of one possiblity has no effect on the other. However, a problem arises when quantum theories are introduced, the outcomes come from a single piece of hardware existing in two seperate realities and these realites overlap one another affecting both outcomes at once. These problems can become one of the greatest strengths

of the new computer however, if it is possible to program the outcomes in such a way so that undesirable effects cancel themselves out while the positive ones reinforce each other. This quantum system must be able to program the equation into it, verify it’s computation, and extract the results.

Several possible systems have been looked at by researchers, one of which involves using electrons, atoms, or ions trapped inside of magnetic fields, intersecting lasers would then be used to excite the confined particles to the right wavelength and a second time to restore the particles to their ground state. A sequence of pulses could be used to array the particles into a pattern usuable in our system of equations. Another possibility by Seth Lloyd of MIT proposed using organic-metallic polymers (one dimensional molecules made of repeating atoms). The energy states of a given atom would be determined by it’s interation with neighboring atoms in the chain. Laser pulses could be used to send signals down the polymer chain and the two ends would create two unique energy states. A third

proposal was to replace the organic molecules with crystals in which information would be stored in the crystals in specific frequencies that could be processed with addtional pulses.

The atomic nuclei, spining in either of two states (clockwise or counterclockwise) could be programmed with a tip of a atomic microscope, either “reading” it’s surface or altering it, which of course would be “writing” part of information storage. “Repetitive motions of the tip, you could eventually write out any desired logic circut, ” DiVincenzo said. This power comes at a price however, in that these states would have to remain completely isolated from everything, including a stray photon. These outside influences would accumulate, causing the system to wander off track and it could even turn around and end up going backward causing frequent mistakes.

To keep this from forming new theories have arisen to overcome this. One way is to keep the computations relatively short to reduce chances of error, another would be to restore redundent copies of the info on seperate machines and take the average (mode) of the answers. This would undoubtedly give up any advantages to the quantum computer, and so AT&T Bell Laboratories have invented an error corrction method in which the quantum bit of data would be encoded in one of nine quantum bits. If one of the nine were lost it would then be possible to recover the data from what information did get through. This would be the protected position that the quantum state would enter before being transmitted. Also since the states of the atoms exist in two states, if one were to be corrupted the state of the atom could be determined simply by observing the opposite end of the atom since each side contains the exact opposite polarity.

The gates that would transmit the information is what is mainly focused on by reasearchers today, this single quantum logic gate and it’s arrangement of components to perform a particular operation. One such gate could control the switch from a 1 to a 0 and back, while another could take two bits and make the result 0 if both are the same, 1 if different. These gates would be rows of ions held in a magnetic trap or single atoms passing through microwave cavities. This single gate could be constructed within the next year or two yet a logical computer must have the millions of gates to become practical.

Tycho Sleator of NYU and Harald Weinfurter of UIA look at the quantum logic gates as simple steps towards making a quantum logic network. These networks would be but rows of gates interacting with each other. Laser beams shining on ions cause a transition from one quantum state to another which can alter the type of collective motion possible in the array and so a specific frequencies of light could be used to control the

interactions between the ions. One name given to these arrays has been named “quantum-dot arrays” in that the individual electrons would be confined to the quantum-dot structures, encodeing information to perform mathmatical operations from simple addition to the factoring of those whole numbers.

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