Divide and conquer for quantum computers

One way to get a job done faster is to divvy it up into small chores that different people can do simultaneously. The same strategy can be applied to solving certain computational problems by breaking them up into components that are distributed among many computers working in parallel.

In principle, a quantum computer (SN: 1/14/95, p. 30) offers an alternative approach to speeding up lengthy calculations (SN: 5/14/94, p. 308). Now, Lov K. Grover of Bell Labs in Murray Hill, N.J., has found a way in which quantum computers can also be made to work in parallel, considerably speeding up a quantum computation.

The significance of Grover's work on what he calls "quantum telecomputation" is that it pioneers the study of an important question, says theoretical physicist John Preskill of the California Institute of Technology in Pasadena. "How can the task of performing a quantum computation best be distributed among many processors?"

The finding follows up on Grover's remarkable discovery last year that, in theory, a quantum computer can search an unsorted database to locate a specific entry more efficiently than a conventional computer can (SN: 8/31/96, p. 143).

Grover's initial interest was in exploiting quantum mechanical effects to develop an efficient procedure, or algorithm, for solving an important type of problem in computer science. The task is to estimate the mean value of a large set of numbers in such a way that the estimated value has a high probability of being within a specified range of the true mean. The closer the estimated value must lie to the true mean, the more numbers must be randomly selected from the entire group to calculate that value and the longer the computation takes.

In Grover's scheme, each number is represented as a quantum mechanical particle (such as an electron), and its value is encoded as the particle's phase. The phase is a wavelike property intrinsic to the particle that allows interference between particles in the same way that wave crests and troughs nullify each other when ripples meet.

By manipulating the phases of all these particles in the same manner, it's possible to obtain an estimate of the mean, derived from the quantum state of the entire ensemble, in fewer steps than a conventional computer would take to do the same calculation.

The computation can be speeded up if the operations are shared among a number of processors. In conventional computing, each processor would simply calculate the exact mean of a certain fraction of the numbers and transmit the resulting value to a central processor, which would then assemble the data and calculate the overall mean.

In Grover's quantum mechanical algorithm, however, each processor computes the approximate mean of the whole group to a certain precision. Consequently, there's no simple way of partitioning the calculation among several quantum processors.

Grover's alternative approach takes advantage of a phenomenon known as quantum entanglement. The idea is to set up a large system that exists in two quantum states at the same time. The act of observation then determines which state is manifest at any given moment.

Scientists have created such entangled states in an electron orbiting an atom (SN: 8/26/95, p. 133) and in a single atom (SN: 5/25/96, p. 325). In both cases, the particle appears to be in two well-separated positions at the same time.

Grover proposes the possibility of representing numbers as entangled particles, each of which is a combination of two states. The particles can then be physically separated among individual quantum processors that independently compute the mean of the ensemble to a certain precision. Because the parallel processors are already linked through quantum entanglement of the particles, only a minimal amount of data finally needs to be transmitted to a single processor to obtain the final result.

"By exploiting their shared entanglement, the processors can get the job done faster than one processor acting alone," Preskill says.

The prospects of achieving practical quantum telecomputation any time soon appear dim, however. "This is a tremendously difficult thing to do [in the lab], but as far as we know, the laws of physics don't make it impossible—only somewhat improbable," says Norman Margolus of Boston University. "By investigating the theoretical limits of quantum computation without worrying about the practicality, Grover and others are helping to stimulate continued interest in the field." —*I. Peterson*

Clinton calls for ban on human cloning

A federal bioethics panel wants Congress to ban attempts to create a human being by cloning, but the group stops short of prohibiting research on cloned human embryos. President Clinton sent legislation embodying these recommendations to Congress this week.

The President asked the National Bioethics Advisory Commission—18 medical, legal, and ethics experts—to review the prospect of human cloning after Scottish researchers created a lamb from a cell of an adult sheep (SN: 3/1/97, p. 132). The panel now concludes that it would be "morally unacceptable for anyone in the public or private sector . . . to attempt to create a child" by implanting cloned embryos in a woman.

Although no federal money can be used to support research on human cloning, no specific U.S. law forbids it. "A motivated person and technician could collaborate at an infertility clinic to do this," says Alta Charo, a panel member from the University of Wisconsin-Madison.

Moreover, the cloning technique used by the Scots would pose great risks to humans, the panel says. Before successfully cloning a lamb, the researchers failed 277 times, producing many abnormal and stillborn animals, Charo says.

The cloning debate pits some fertility clinics, which want cloning explored to open possible options for infertile couples, against abortion foes, who believe that life starts at conception and want to stop all cloning work with human embryos.

Most biotechnology research that might use cloning focuses on animals and thus falls outside this debate. For example, much genetic work uses animals as models of human disease—a process that often involves placing human genes in the animals. Other scientists aim to develop animals whose organs could be transplanted into humans. The Scottish researchers are trying to create animals that secrete beneficial drugs in their milk. Once scientists have created a particular useful animal, cloning would enable them to recreate it many times over.

The leap from duplicating animals to cloning people raises moral questions that lie at the heart of the panel's recommendation. A child born of cloning would face "an enormous weight of social and parental expectations about what and who that child should be," says panel member Ezekiel Emanuel of the Dana-Farber Cancer Institute in Boston.

Nonetheless, childless couples may someday want the option of cloning themselves, and those who have one child but then become sterile might hope to clone that child, in effect creating a later-born identical twin, says molecular biologist Lee Silver of Princeton University. He applauds Clinton's proposal that the law be revisited after 4 1/2 years to review the state of the science.

"In the long run, human cloning is a sideshow," says Arthur Caplan of the Center for Bioethics at the University of Pennsylvania in Philadelphia. "It's an oddball little subset of genetic engineering."

A more immediate concern, Caplan says, is that the debate over cloning may spur a backlash against genetic research in general. —*N. Seppa*