IT Watch: Molectronics and Biological Computing

Dr. M. Jameel

This is not a science fiction. The world seems to be on the brink of a new technological revolution that we have not seen before. In October 2001, it was announced that scientists from Lucent Technologies Bell Labs built the world's smallest transistor. The scientists fabricated for the first time an individually addressable transistor whose channel consists of just one molecule. A molecular scale transistor is roughly considered a million times smaller than a grain of sand. Due to its potential applications, this nanotechnology event is considered the top scientific breakthrough of 2001 by the Science magazine.

To understand the impact of current discovery, we need to briefly look where we were in the last 50 or so years. In 1947, Bell Labs scientists developed the world's first solid-state amplifier called transistor, which essentially replaced vacuum tubes used in electronic devices. Before transistor, the word "electronics" meant a branch of physics concerned with the behavior of electrons in a vacuum. The transistor started the foundation for the solid-state microelectronics revolution that continues till today. The transistor and integrated circuits allowed portable radio, manned space flight, smaller computers, and many other applications. The miniaturization allowed us to do tasks that could not have been done by hot bulky vacuum tubes. In late 60s researchers proposed that a computer can be made on a chip and by 1971 the first working microprocessor (4004) was built by Intel containing around 2300 transistors. Nowadays, a microprocessor contains millions of transistors and the miniaturization is still creating doubling of CPU speed every 18 months.

Let us first checkout nanotechnology. Remember, a nanometer is one billionth of a meter. The thickness (diameter) of a human hair is about 200,000 nanometers. You need to line up about 4 to 5 atoms to form a nanometer. For another analogy, imagine a cricket ball as the size of earth then an atom would be around the size of a cherry. A molecule consists of a single atom or a group of atoms linked together and nanotechnology at the molecule level is creating a lot of excitement for researchers around the world. In simple terms, nanotechnology is a science that manipulates matter on a scale of 1 to 100 nanometers across.

Nantotechnology research is being focused in areas such as medicine, environmental engineering, mechanical devices, drug delivery devices, sensors, and information technology. Nanotechnology leads to the next industrial age. According to Red Herring magazine, governments from United States, Europe, and Japan alone will spend $1.65 to 1.75 billion on basic nanotechnology research in the year 2002. Various universities and laboratories in the United States, Europe, and Asia are performing research in this field. Many investment firms are also getting into the action by investing a lot of money in various nanotechnology areas.

Obviously, there are physical limits for the continued miniaturization in electronics. Current silicon-based technology using lithography is expected to be practical only up to 100-nanometer level. Some people believe we will be approaching to these limits within the next two decades. So to create cheaper and faster computer, researchers are looking how to break these barriers through a different way of thinking about information and technologies, especially with nanotechnology. Due to collective focus of interdisciplinary sciences, Molectronics (Molecular-scale Electronics) and biological computing fields are getting a lot of attention. Collaboration of disciplines such as Physics, Chemistry, and Engineering is giving us Molectronics and collaboration of Biology, Biochemistry, and Computer Science is yielding promise in the areas of biological computing.

Molecular electronics is being considered an emerging field. It opens the possibility to build individual molecules that can perform similar functions as currently performed by the transistors, diodes, conductors, and other key computer logic components. On the molectronics front, many early steps have been demonstrated. We now have to deal with new words or phrases such as nanowires, nanotubes, single molecules as switches, molecules functioning as random-access-memory devices, and molecular-scale transistors. Many milestones such as a nanoscale transistor that can be switched on and off with a single electron, multiple-transistor logic circuit with nanotube field-effect transistors, single molecule logic gates, and wiring a single molecule into an electrical circuit by chemically bonding the molecules' two ends to metal conductors have already been achieved. So watch out for more progress in the coming years.

Biological computing, sometimes called bio-informatics, is the other area worth tracking. Computers today use binary code (1 and 0) to perform calculations. Knowing that DNA molecule is also a code made up of a sequence of four bases, research scientists are using the code property of DNA to invent a molecular computer. DNA-based computing is being researched to encode, store, compute, and retrieve non-biological information. It is believed that one gram of DNA can store more than 4 billion trillion bits. So research is also being done in creating large-scale DNA databases. Its expected inputs and outputs encoded by DNA strands will support massively parallel computations. Furthermore, replicating a programmed cell in billions is expected to be cheaper than today's manufacturing processes.

At present, United States, Japan, and Europe are leading the world in nanotechnology areas. However, the technology has started to spread globally in Research & Development labs. With the limited research funding in Pakistan, it is not clear if any institution in is involved in tracking some of these future technologies and making assessments for future direction. However, many other Asian countries are now participating through various organizations for knowledge transfer and research in this area.

So, what is in store for us in the future? Based on the previous inventions of similar kind, it looks that the new technological revolution is starting. These areas are expected to create next industrial age for our future. The initiatives taken by various governments and the amount of funding available for year 2002 suggest that nanotechnology in general is no longer considered as a theoretical research. The new initiatives are now focused in finding application-oriented results. These technologies seem to have a great potential and some initial building blocks are now emerging. However, real applications are many years away in the future. These technologies some day may provide us ultra small and ultra dense computers, databases, and other applications. We have high expectations of our global team of biologists, chemists, physicists, engineers, and researchers in other disciplines to transform these initial steps into reality.

Even rats have sweet dreams: scientist

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By Tim Radford

BOSTON: Even rats have sweet dreams, according to a US scientist. He wired up the brains of sleeping rodents, and eavesdropped as they dreamed of their adventures in a psychologist's maze.

This was the first time that researchers had been able to tune into animal dreams, Matthew Wilson of the Massachusetts Institute of Technology centre for learning and memory, told the American Association for the Advancement of Science in Boston on Tuesday.

"No one knew for certain that animals dreamed the way we do, which can involve replaying events or at least components of events that occurred while they were awake," he said. "We looked at the firing patterns of a collection of individual cells to determine the content of rats' dreams. We know that they are in fact dreaming, and their dreams are connected to actual experiences."

Armed with a proven technique, researchers may be able to analyse the content of dream states in other animals and even humans. It could provide a tool for treating memory disorders. It might offer a way to help people learn and memorise more effectively.

He trained rats to run around a track for a food reward, and monitored the brain patterns. As it ran, a rat's brain created a distinctive pattern of nerve cell firings in the hippocampus, an area of the brain linked with memory.

He and colleagues then watched the rats while they slept through more than 40 episodes of rapid eye movement, or REM sleep. About half repeated the unique signature of the waking activity.

The researchers found that as an animal dreamed, they could reconstruct where it would be in the maze if it were awake, and whether it was dreaming of running, or standing still. "It has been a century since Freud brought forward the study of the subconscious and the examination of the content of dreams as a tool for understanding," he said. "We now have the means to bring this world of dreams into the study of animal cognition, and gain deeper insight into our own."

Humans seem to "learn" during REM sleep. Both humans and animals have shown in tests that they perform a recently mastered task better after sleeping on it. There have been reports of people waking up with an answer to a problem that has been worrying them for days.—*Dawn/The Guardian News Service*