Innovations Report

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ICT

Beaming the internet across Europe: new project aims to connect buildings using antennae not wires

Developing ways to connect homes and businesses to the internet without using wires is the aim of a new project announced today. The research at Imperial College London could help users across Europe to access the internet, by removing the need to lay out connecting phone lines or other cables between the public internet and a user's building or network.

At present, although it is possible to make use of wireless technology within homes and office buildings, the connection from these buildings back to the public internet requires wires. External routers connect local area networks to the public internet through strings of phone lines, 'T1' lines or optical fibres. The new project, which sees Imperial working with academic and industrial partners across Europe, aims to use wireless links with advanced antennae instead of such wires to beam a radio signal between buildings' local area networks and external routers. A mesh of routers beaming data between them would form a wireless network which would relay data to and from the public internet.

The use of wireless technologies has the potential to greatly increase access to the internet for users in urban areas and also in remote areas where it might be costly or physically difficult to lay out wires. It is also anticipated that a network using multiple-input-multiple-output (MIMO) antennae would be able to carry data at very high speeds. In comparison, present wired technologies such as ADSL and T1 lines can carry a more limited amount of data than the wireless network, and optical fibres can carry high amounts of data but are relatively expensive.

Issues that the project will be tackling include making certain that networking technologies can work efficiently with the MIMO antennae design, ensuring that the electro-magnetic waves from the antennae head in precisely the right direction and minimising any radio interference that these waves might cause.

Professor Kin Leung, project coordinator, said: "The internet has become an integral part of our daily life and continues to grow. Instead of relying on the use of traditional wired lines, we need to explore alternative, efficient technologies to connect users in homes and office buildings to the internet. "Our challenge here is to invent an integrated set of new antennae and wireless networking technologies that can work together efficiently to meet such needs. We are hoping that we could see this technology in use within the next five to ten years," he added.

The project, named MEMBRANE (Multi-Element Multihop Backhaul Reconfigurable Antenna Network), is expected to run until June 2008, by which time the project team are hopeful they will have built a prototype of the key elements of the new wireless network.

The Imperial researchers are working on the project alongside partners from Lucent Technologies, ETH Zurich, Intel, CEFRIEL, Intracom and Telefonica. The MEMBRANE project is part-funded with €2.8 million by the European Community's 6th Framework Programme

Breakthrough In Semiconductor Spin Wave Research

UCLA prof. Eshaghian-Wilner and colleahue have created three novel nanoscale computational architectures using a technology they pioneered called “spin-wave buses” as the mechanism for interconnection. The three nanoscale architectures are not only power efficient, but also possess a high degree of interconnectivity.

“Progress in the miniaturization of semiconductor electronic devices has meant chip features have become nanoscale. Today’s current devices, which are based on complementary metal oxide semiconductor standards, or ‘CMOS,’ can’t get much smaller and still function properly and effectively. CMOS continues to face increasing power and cost challenges,” Wang said.

In contrast to traditional information processing technology devices that simply move electric charges around while ignoring the extra spin that tags along for the ride, spin-wave buses put the extra motion to work transferring data or power between computer components. Information is encoded directly into the phase of the spin waves. Unlike a point-to-point connection, a “bus” can logically connect several peripherals. The result is a reduction in power consumption, less heat and, ultimately, the ability to make components much smaller as no physical wires are actually used to send the data.

“Design of nanoscale architectures for computing is a very new area, but an important one for the future. In order to produce effective nanoscale devices, we need to actively look at new low power designs that can have efficient interconnectivity and allow scaling beyond current barriers,” Eshaghian-Wilner said “And now we’ve made a significant effort to demonstrate the operation of spin-based devices at room temperature .Our experimental results confirm the intriguing fact that information can be transmitted via spin waves propagating in spin waveguides — ferromagnetic films.”

UCLA Engineering’s team contends that the creation and detection of spin-wave packets in nanostructures can be used efficiently to perform massively parallel computational operations, allowing for the design of the first practical, fully interconnected network of processors on a single chip. This breaks with currently proposed spintronic architectures, which rely on a charge transfer for information exchange and show significant interconnect problems.

The first device developed by UCLA engineers, described in a paper presented publicly at the annual ACM International Conference on Computing Frontiers in May. The second architecture invention, details of which will be published at the Nanotech Show 2006 The researchers also have developed a spin-wave-based crossbar for fully interconnecting multiple inputs to multiple outputs, and plan to announce the full details of the design at the 2006 IEEE Conference on Nanotechnology in July.

Currently, various extensions and applications of these three designs are being studied and evaluated by the UCLA Engineering team and their students: image processing, neural computations, bioinformatics and implantable biomedical devices e.g.. Heterogeneous integrations of these designs in a complementary fashion with other molecular and nanotechnologies also are being developed.

12-qubits Reached In Quantum Information Quest

Theorists and experimentalists at the Institute for Quantum Computing (IQC) and Perimeter Institute for Theoretical Physics (PI) in Waterloo, along with MIT, Cambridge, have presented an operational control method in quantum information processing extending up to 12 qubits. The team's research is available in Physical Review Letters (PRL 96, 170501 week ending 5 May, 2006) and describes the approaches, accuracy and scalability. Despite decoherence, the researchers reached a 12-coherence state and decoded it using liquid state nuclear magnetic resonance quantum infomation processors.

The Director IQC Institute says: "... our experiment shows a high level of quantum control over the largest quantum register to date. It is an important step in implementing quantum information processing on larger and larger devices. This is an important milestone towards harnessing the quantum world."

The team's findings set a new algorithmic benchmark in a global effort to exploit quantum properties in order to support entirely new modes of information processing -- such as quantum computers with an ability to solve certain types of incredibly complex problems that no modern day computer can approach. The basic principles behind today's computers and other information processing devices (known as "classical" systems) were developed in the 1930s. However, today's theories governing the calculation, storage and transmission of information are at a crossroads. As wires and logic gates become ever smaller, quirky quantum phenomena in the tiny world of atoms take over and impede the efficient flow of information. Select groups of international theorists and experimentalists - including those who are clustering in Waterloo, Ontario - are trying to understand and harness the phenomena and, with this latest research, have set a new standard by controlling a 12-Qubit system.

Microelectronics & Nanotech

Strained silicon as a new electro-optic material

For decades, silicon has been the material of choice for mass fabrication of electronics. This is in contrast to photonics, where passive optical components in silicon have only recently been realized. The slow progress within silicon optoelectronics, where electronic and optical functionalities can be integrated into monolithic components based on the versatile silicon platform, is due to the limited active optical properties of silicon. Recently, however, a continuous-wave Raman silicon laser was demonstrated; if an effective modulator could also be realized in silicon, data processing and transmission could potentially be performed by all-silicon electronic and optical components. Scientists from the Technical University of Denmark have now discovered that a significant linear electro-optic effect is induced in silicon by breaking the crystal symmetry. The symmetry is broken by depositing a straining layer on top of a silicon waveguide, and the induced nonlinear coefficient, makes it possible to realize a silicon electro-optic modulator. The strain-induced linear electro-optic effect may be used to remove a bottleneck in modern computers by replacing the electronic bus with a much faster optical alternative.
The article on their work appears in the Nature 441 issue.

Nanotube Sandwiches Could Lead To Better Composite Materials

By stacking layers of ceramic cloth with interlocking nanotubes in between, a team of researchers from Rensellaer and Univ. Of Hawaii-Manoa, has created new composites with significantly improved properties compared to traditional materials. The "nanotube sandwiches," which are described in the May edition of Nature Materials, could find use in a wide array of structural applications.

"Nanotubes are a very versatile material with absolutely fascinating physical properties, all the way from ballistic conduction to really interesting mechanical behavior," says the lead author of the paper. Some fundamental issues, however, have kept researchers from realizing the full potential of nanotubes, particularly when combining them with other materials to make composites. The interface between the materials is not as strong as one might expect because it is difficult to disperse nanotubes and to align them in an orderly way. This is the main difficulty the current work has pioneered to overcome in the specific area of reinforced composite fabrics made from woven ceramic fibers.

These materials have been used for decades in structural applications, but they tend to perform poorly in terms of "through-thickness," or the ability of a material to respond to forces applied perpendicular to the fabric-stacking direction. "We have demonstrated that these through-thickness properties can be improved by adding nanotube Velcro-like structures between the layers," says one of the authors. To make the new materials, the researchers deposit a forest of carbon nanotubes across the surface of a cloth woven from fibers of silicon carbide -- a ceramic compound made from silicon and carbon. The fabric layers are infiltrated with a high-temperature epoxy matrix, and then several layers of cloth are stacked on top of each other to form a three-dimensional composite "sandwich," with interlocking nanotubes acting to fasten the layers together.

The researchers ran several experiments to test the new material's properties, and they found that the interlocking nanotubes provided remarkable improvements in strength and toughness under various loading conditions. The materials performed extremely well in fracture tests, and they demonstrated a five-fold increase in damping -- or the ability to dissipate energy -- over the original ceramic composites without nanotubes included. This suggests that the new composites could be used in many applications where mechanical properties are important, from automobile engines to golf club shafts.

Tests also showed that both the thermal and electrical conductivity of the new composites were significantly improved, which means that they could potentially be employed as sensors to monitor crack propagation in various structures, the researchers note.

Scientists Create The First Synthetic Nanoscale Fractal Molecule

From snowflakes to the leaves on a tree, objects in nature are made of irregular molecules called fractals. Scientists now have created and captured an image of the largest man-made fractal molecule at the nanoscale.
The molecule, developed by researchers at the University of Akron, Ohio University and Clemson University, eventually could lead to new types of photoelectric cells, molecular batteries and energy storage, according to the scientists, whose study was published on the journal Science.

A University of Akron research team led by George Newkome used molecular self-assembly techniques to synthesize the molecule in the laboratory. The molecule, bound with ions of iron and ruthenium, forms a hexagonal gasket. Ohio University physicists Saw-Wai Hla and Violeta Iancu, who specialize in imaging objects at the nanoscale, confirmed the creation of the man-made fractal. Though invisible to the naked eye, the objects are 12 nanometers wide
Researchers were also able to measure the electronic structure of the molecule. “(The molecules) are unique in their own way”

Life Sciences

MIT nanoparticles may help detect, treat tumors

A new technique devised by MIT engineers may one day help physicians detect cancerous tumors during early stages of growth.

The technique allows nanoparticles to group together inside cancerous tumors, creating masses with enough of a magnetic signal to be detectable by a magnetic resonance imaging (MRI) machine. The work appears as the cover feature in the May issue of Angewandte Chemie International Edition

The research, which is just moving into animal testing, involves injecting nanoparticles (billionths of a meter in size) made of iron oxide into the body, where they flow through the bloodstream and enter tumors. Solid tumors must form new blood vessels to grow. But because this growth is so rapid in cancerous tumors, there are gaps in the endothelial cells that line the inside of the blood vessels. The nanoparticles can slip through these gaps to enter the tumors. Once inside the tumor, the nanoparticles can be triggered to group together by a mechanism designed by the MIT engineers. Specifically, certain enzymes, or proteases, inside the tumors cause the nanoparticles to "self-assemble" or stick together. The resulting nanoparticle clumps are too big to get back out of the gaps. Further, the clumps have a stronger magnetic signal than do individual nanoparticles, allowing detection by MRI.

The technique initially is being used to study breast tumors and it eventually may be applied to many different types of cancers and to study the "triggers" that turn a benign mass in the body into a cancerous tumor. Nanoparticles also hold the promise of carrying medicines that could kill cancer cells, replacing radiation or chemotherapy treatments that cause negative side effects such as hair loss or nausea.

Self-repair gene therapy promise

Gene therapy experts say they have found a way to persuade cells to repair themselves.
Instead of replacing a faulty gene, the new approach harnesses the cells' own correctional mechanisms. German researchers showed a drug could influence the way a gene behaved in patients with a debilitating genetic condition.
Details of the research are being presented to the European Society of Human Genetics conference in Amsterdam.

The research focussed on spinal muscular atrophy (SMA), a relatively common inherited disease, and the leading cause of death in infants, affecting about one in every 6,000 newborns. Due to degeneration of the motor neurons in the spinal cord patients develop muscle weakness and atrophy of the legs, arms and trunk. In patients with SMA the survival motor neuron gene (SMN1) is deleted, but they all carry a copy gene (SMN2). However, this only produces about 10% of the correct protein which is insufficient to prevent the diseases. The severity of the SMA is influenced by the number of SMN2 genes, which normally vary between one and four - the more copies there are the better the patient fares.

The researchers, from the Institute of Genetics at the University of Cologne investigated a drug called valproate. Lab tests had shown it could increase levels of the SMN protein by up to four times. Valproate was also found to raise SMN levels in brain tissue.
However, it remains unclear whether SMN expression in blood reflects SMN expression in motor neurons, and would therefore have an effect on muscle strength. But the researchers said they hoped their findings could have significant benefits in the future.

Dr Fred Kavalier, of the British Society of Human Genetics, said: "This work shows that it may be possible to influence the behaviour of genes with drugs.

Professor Robin Lovell-Badge, head of genetics at the Medical Research Council's National Institute for Medical Research, said it was crucial to obtain detailed basic understanding of specific genes, and the nature of the defects responsible for genetic disease before the knowledge was applied to treating patients.."

Cancer destroyed by Antibody Triple Shot

A new cancer therapy using a triple shot of antibodies has shown unprecedented success in mice. Not only does the treatment destroy tumours – even when they have spread around the body – it also prevents the tumours coming back. And the approach should work for a range of cancers. Success in mice is far from a guarantee of success in people, but human trials have now begun on one component of the therapy.

The research, by scientists of the Cancer Center of Australia and Juntendo University School of Medicine in Japan, is “an exciting advance”, according to experts: “This novel form of therapeutic vaccination would not only enable potent tumour eradication but also protect from recurrence.”

The idea of using the body’s immune system to kill cancerous cells is already routinely deployed. Our immune system contains killer white blood cells called cytotoxic T lymphocytes (CTLs), which single out and destroy tumours. But the body’s natural response to cancerous cells is often not strong enough to wipe out the tumour.
The new therapy, called TrimAb (triple monoclonal antibody) therapy, may solve that problem. The first attacks the tumour directly, by stimulating the receptor for a death-inducing protein on tumour cells, called TRAIL. The boost that strengthens the response comes from the other two antibodies which activate killer T-cells that pitch in to kill the tumour.

TrimAb cleared large breast tumours in 80% of the mice that received the treatment, while the tumour disappeared in less than 30% of mice that got either single antibodies or double antibody combinations. And furthermore, the therapy induced a complete cure in 60% of the mice in which the breast cancer had spread to the lungs, liver, and brain.

TrimAb causes T-cells to produce an immune molecule named interferon gamma. This molecule is key to tumour destruction.
Many cancers express TRAIL, so TrimAb is not just specific for breast cancers. In particular, it works for renal cancer and sarcomas, and colon cancer is a promising target.

TrimAb prevents the recurrence of cancer because destroying the tumours presents the immune system with antigens, priming it for the future. A specific advantage of this is that the immune system is then primed against that particular tumour.

Clearing protein 'smokescreen' helps battle cancer

Tumours put up a protein "smokescreen" to escape the body’s immune system, and blocking those proteins helps kill cancer cells in mice, a new study has found. The work also offers new insight into why some inflammatory diseases increase a person’s risk of cancer.
The immune-system protein that appears to help tumours escape attack is called cytokine interleukin 23 (IL-23). High levels of IL-23 were found in the human tumours studied by Martin Oft at the Schering-Plough Institute in Palo Alto, and his colleagues. The team also found that mice deficient in IL-23 did not develop as many tumours as normal mice.

Under ordinary circumstances, IL-23 contributes to the recruitment of cells known as neutrophils. These play an important role in the early immune response to an infection, targeting foreign particles in the body. The task of infiltrating diseased tissues and rooting out the source of an illness belongs to another kind of immune cell called CD8 T-cells, and it is these cells that IL-23 appears to repel. In the case of cancer, excess IL-23 prevents the CD8 T-cells from eliminating a tumour.

The team's work also addresses the link between chronic inflammation and cancer, which doctors have suspected for more than a century. For example. some inflammatory illnesses – such as psoriasis and inflammatory bowl disease – are associated with an increased cancer risk.
The team's work explains this link because earlier work has shown that excess IL-23 in the body appears to drive chronic inflammatory disease.

Journal reference: Nature