Innovations Report

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ICT

Computers Everywhere: Embedded Software Made Simpler Yet More Powerful

The current decade will probably be known as the dawn of pervasive computing, when PCs were dethroned by technology to embed computers in almost everything. The hardware already exists to add features such as artificial intelligence and wireless connectivity to clothing or cars. Thanks to researchers, software is catching up fast.

“Hardware development has reached a stage where it is possible to have a fully-fledged computer with processor, memory and operating system on a board the size of a sliver of chewing gum,” explains Germán Puebla, of Madrid Technical University. “But until now software that can be programmed easily, and uses the limited hardware and power resources of pervasive computing devices as efficiently as possible has been lacking.” Puebla coordinated the ASAP project, which, with funding from the European Commission’s Future and Emerging Technologies initiative, set out to solve the problem of creating and adapting software to run efficiently on pervasive computing systems, where computers are integrated in everyday objects and environments.

The result is a groundbreaking open source programming, analysis and optimisation toolkit for pervasive computing systems using Constraint Logic Programming (CLP) languages that has been validated in a series of case studies. The decision to use CLP for pervasive computing not only represents a clean break from the norm, but a major innovation that will smooth the rollout of more complex software for the tiny ubiquitous computers of the future.

Until ASAP, the use of high-level CLP languages, which simplify programming and make software more portable across different platforms, had not been considered a feasible solution for pervasive systems because the convenience they provide to programmers comes at a cost: generally less efficient and more resource-hungry code. Therefore, researchers have traditionally used low-level languages such as C, which tend to be more efficient but also more complicated to code, limits the versatility and complexity of the software, and generally forces programmers to manually rewrite the program for different platforms.

ASAP’s toolkit, developed jointly by the Technical University of Madrid (UPM), Heinrich-Heine University of Düsseldorf, and Roskilde University (RUC), offers a solution by using the high-level declarative language Ciao in a way that is optimised to reduce resource consumption.

Self-tuning and resource-aware analysis and specialisation algorithms allow the toolkit, dubbed CiaoPP, to produce specialised programs that are automatically optimised to meet particular processing and resource constraints. The CLP analysis and transformation tools can also act as a meta-language between a broad range of high and low-level languages to optimise and verify programs for pervasive computing. Because of the automatic nature of the tools and the limited need for manual programming, the risk of errors being introduced into the code is also reduced.

Getting Fiber to Homes Faster

Circuits that integrate electronics and optical components might help spread the fiber revolution

A new circuit that combines electrical and optical components could speed the deployment of fiber-optic networks to homes, which would usher in a host of new services, including Internet-protocol television. The technology is currently being developed by a handful of companies in both the United States and Japan.

Today, fiber-to-the-home (FTTH) is available in only about 15 U.S. cities, as well as some urban areas in Japan, Korea, and China, in part because it takes a huge investment of time and money to build all the infrastructure: to dig new trenches, to lay new fiber, and to install the fiber utility box on homes. But there's another hold up: it's expensive to manufacture and deploy all the individual optic-fiber devices, called "triplexers," that must be affixed to houses. These triplexers, which come into play where the fiber connects to the home, contain the electrical and optical components that guide and collect the data-carrying photons that become Web pages, telephone calls, or video.

While new technology may do little to solve the problem of ditch-digging, it could make it much cheaper to produce triplexers, by integrating multiple functions onto a single chip. This technology, called a planar lightwave circuit (PLC), is already used in some fiber network applications. But there it integrates only optical components -- for applications such as triplexers, the chip needs to incorporate both electrical and optical components.

The optical structures in a triplexer, the waveguides and filters, direct the incoming information and split the photons delivered through the fiber-optic pipes into two wavelengths (1,550 nanometers carries analog information such as video and 1,490 nanometers carries data such as Internet and voice). Meanwhile, one type of electrical component, small detectors, collects the photons coming into the home, while another, lasers, produce light (at 1,310 nanometers) that sends information away from the home (say, an e-mail or phone call). Today's triplexers are made in two separate steps: optical waveguides are deposited on a chip, and then separately housed lasers and detectors must be carefully aligned and attached to the waveguides. Since much of the alignment must be done manually, manufacturing is costly and time-consuming.

The new triplexer PLC technology is able to integrate optical and electrical components onto a single chip by borrowing well-honed processes from semiconductor chip manufacturing.

Although it's still in the testing phase, this kind of device could ultimately drive down the price of producing fiber-optic connections to homes and buildings..

Scottish city to pioneer personalised local wireless information

Dundee today moved a step closer to becoming Scotland’s city of wireless innovation, with the announcement of a partnership between the University of Abertay Dundee and LastMile Communications, the British company pioneering a wireless delivery platform using WiFi.

Under the agreement, the Abertay campus will become a test bed for LastMile’s state-of-the-art node-based wireless information system. The technology offers end user-focused content to mobile devices on demand, and tailored precisely to their location.
In specific, LastMile has designed a node-based content delivery platform, which allows information to be stored and processed at the edge of the network, rather than at the centre as with most conventional networks. Because of this, it reduces the need for unnecessary network traffic by putting processing and information within the network itself, enabling users to access information more quickly and make existing networks more efficient.

UK project seeks to build multiple-hop antenna

Entire communities may soon be networked by meshes of radio transmissions that will carry much more data than existing wired services. A new kind of antenna will act as a relay node, forwarding signals through the air to link eventually with the public internet or private networks.

The project depends upon perfecting the multiple-input-multiple-output (MIMO) antennas and the algorithms and protocols that will maximise their efficiency. 'Essentially MIMOs behave like a lot of mini antennas in one,' said research co-ordinator Prof Kin Leung of Imperial College London. Industrial collaborators include Lucent Technologies, ETH Zurich, Intel, CEFRIEL, Intracom and Telefonica.

The aim is to design a system where signals hop from one antenna to the next, following reconfigurable routes that optimise the network. 'It's relatively challenging to build a multiple hop system,' said Leung. 'The hops could be as short as 100m or as long as a few kilometres. In rural areas directional antennae with line of sight could cover even greater distances.'

The researchers are not yet targeting a specific frequency band although the technology may be best suited for the lower end of the available spectrum, perhaps around 1900mHz used by 3G. 'We are still looking at it as a generic issue,' said Leung, whose programme has two years to run.

Present wired technologies such as ADSL and T1 lines can carry only a limited amount of data compared to the planned wireless system. T1 is rated at 1.544 Mb/sec and Leung's team is to exceed that capacity several times over. Although optical fibres already exceed these speeds they are relatively expensive to install. The team hopes that wireless will combine high speed and low cost.

Ultra-Low-Power Cell Phones

Programmable analog circuits could drastically reduce the power needs and cost of electronics in portable devices.

A radical approach to making the electronics in cell phones could cut the power consumption of cell phones anywhere from 10 to 100 times, while also dramatically reducing the size and cost.
The mobile phone of tomorrow faces competing demands: the need for more and more sophisticated ways of dividing up available bandwidth and the need to accommodate ever-more power-hungry processing.
Benjamin Vigoda, at Mitsubishi Electric Research Laboratories in Cambridge, MA, and research associate at MIT, says the solution may come from an unexpected approach: replacing the combination of analog and digital circuitry used today with what he calls "analog logic." Vigoda has already built a prototype chip using his approach, which is now being tested for accuracy, power consumption, and noise, among other things. He says a cell phone using the technology could be completed in five years.

Today's cell phones already use specialized analog components for sending and receiving high radio frequencies, for example, which are too fast for digital processing to handle. Meanwhile, digital components handle computational functions, such as error correction, with programmable, general purpose logic gates. Vigoda's programmable analog devices can replace both the traditional analog and digital components. This saves power in two ways. First, converting between analog and digital is wasteful in both space and power. Going all-analog cuts out the analog-to-digital middleman, thereby reducing the power required. The analog circuits are also more efficient -- Vigoda says one can do the work of 1,000 digital logic gates.
At the same time, Vigoda is keeping the advantages of digital processors by using modular components that permit, for example, an automated design process. Also, because he uses standard CMOS transistors, his new circuits can be built with the same tools developed for the semiconductor industry.

While the new components can replace power-hungry digital chips, they can also replace old analog components, such as oscillators, with analog components that can be programmed. The result would be radios which can produce more complex signals that can be changed "on the fly," Vigoda says, making it possible for many more callers to use the same bandwidth without the signals interfering with each other, as well as making it possible to optimize power savings for different environments.
"For 80 years we've been relying on these special-purpose analog circuits that are designed and set in stone," says Vigoda. "What we can do now is make the radio programmable all the way to the antenna. You can imagine much better system-wide optimization given this flexibility at the physical layer."

I cellulari eccitano il cervello
Lo studio non è in grado di stabilire però se i telefonini facciano male alla salute

Non è ancora chiaro se facciano male alla salute oppure no. Quello che è certo, almeno secondo uno studio italiano che sarà pubblicato sulla rivista scientifica 'Annals of Neurology', è che i telefoni cellulari «eccitano» il nostro cervello. Lo afferma una ricerca condotta congiuntamente dai ricercatori dell'IRCCS Fatebenefratelli di Brescia e, a Roma, dall'Ospedale S.Giovanni Calibita-Fatebenefratelli, dalla Facoltà di Psicologia della Sapienza e dalla Clinica Neurologica all'Università Campus Bio-Medico.

«È dimostrato senza alcuna ombra di dubbio - affermano i responsabili dello studio - che le emissioni elettromagnetiche dei telefoni cellulari producono effetti sull'eccitabilità del cervello di chi li usa, ed in particolare in quella parte delicata che è la corteccia cerebrale». I ricercatori italiani sono partiti da un metodo denominato paired-TMS che consente di misurare l'andamento di eccitazione o inibizione indotto da una coppia di stimoli sulla corteccia cerebrale. Sono stati studiati 15 soggetti volontari, ai quali è stato fatto indossare un elmetto che incorporava due cellulari della generazione GSM, all'altezza dell'orecchio destro e sinistro, in modo da far coincidere il punto di massima esposizione elettromagnetica con la corteccia motoria destra e sinistra, riproducendo le medesime condizioni di un utente che usa il cellulare. I risultati, affermano gli studiosi, sono stati «sorprendenti»: prima dell'accensione dei telefonini, l'eccitabilità delle due metà (emisferi) del cervello risulta identica. La differenza tra i due emisferi diventa invece significativa dopo 45 minuti di esposizione e si mantiene tale anche 60 minuti dopo la disattivazione dei cellulari.

Tale dimostrazione, precisano tuttavia gli autori dello studio, non implica necessariamente la pericolosità dello strumento di telefonia mobile, ma pone l'accento sulla necessità di approfondire gli studi per verificare gli eventuali effetti dannosi su persone che già soffrono di eccitabilità della corteccia, ad esempio i malati di epilessia, o, al contrario, l'eventuale utilizzo dal punto di vista clinico per il trattamento di persone con eccitabilità del cervello particolarmente ridotta, quali ad esempio malati di Alzheimer o pazienti dopo ictus».

Microelectronics & Nanotech

Carbon Nanotube Computers

IBM researchers have made an important breakthrough: arranging nanotube transistors for complex circuits.

Selectively placing carbon nanotubes for transistors could lead to ultrafast, low-power computers. Researchers at IBM have overcome an important obstacle to building computers based on carbon nanotubes, by developing a way to selectively arrange transistors that were made using the carbon molecules. The achievement, described in the current issue of Nano Letters, could help make large-scale integrated circuits built out of carbon nanotubes possible, leading to ultrafast, low-power processors.

For decades, the size of silicon-based transistors has decreased steadily while their performance has improved. As the devices approach their physical limits, though, researchers have started looking to less conventional structures and materials. Single-walled carbon nanotubes are one prominent candidate -- already researchers have built carbon nanotube transistors that show promising performance. According to estimates, carbon nanotubes have the potential to produce transistors that run 10 times faster than even anticipated future generations of silicon-based devices, while at the same time using less power.

But so far research in the field has hit a roadblock: not being able to control the placement of nanotube transistors, making it impossible to build complex integrated circuits. "The way most nanotubes transistor sare made now, nanotubes are randomly dispersed on a surface in solution, then source and drain contacts are randomly printed using lithography, and then you search around until you find by chance a tube that goes between a source and a drain," says James Hannon, one of the researchers involved with the work at IBM.

To gain control over the arrangement of transistors, the IBM researchers coated the nanotubes with molecules that bind only to patterns of metal oxide lines on a surface, and not to the areas in-between. To make working transistors, the researchers laid down lines of aluminum using a lithography technique. These wires serve as the gates that turn the transistors on and off. They then oxidized the aluminum to form a thin aluminum oxide layer on top of the wires, which acts as both a dielectric and the material to which the nanotubes will bind. After applying carbon nanotubes in solution and allowing them to bind to the aluminum oxide, the researchers deposited palladium leads perpendicular to the aluminum/aluminum oxide wires. These leads crossed over the nanotubes, becoming the source and drain of the transistor.

While developing this method of organizing nanotube transistors is an important step, much work remains to be done before commercial processors will be available. For one thing, exploiting the full potential of nanotube transistors will require improving the leads, possibly by using nanotubes in place of the palladium wires.

But perhaps a more pressing problem is finding reliable and inexpensive ways to isolate different types of carbon nanotubes. Current fabrication techniques produce a mix of nanotubes with different sizes and electronic properties, not all of which will work well in integrated circuits.

Because of these challenges, the first applications of carbon nanotube transistors will probably not be as high-performance processors, Hannon says, but highly sensitive sensors that work even with a mix of different nanotubes.

Carbon-based Quantum Dots Could Mean 'Greener,' Safer Technology In Medicine And Biology

Chemists at Clemson University say they have developed a new type of quantum dot that is the first to be made from carbon. Like their metal-based counterparts, these nano-sized "carbon dots" glow brightly when exposed to light and show promise for a broad range of applications, including improved biological sensors, medical imaging devices and tiny light-emitting diodes (LEDs), the researchers say. The carbon-based quantum dots show less potential for toxicity and environmental harm and have the potential to be less expensive than metal-based quantum dots, the scientists say.

Quantum dots have generated much interest in recent years, especially for potential applications in biology and medicine. These tiny particles -- thousands of times smaller than the width of a human hair -- have been developed from compounds composed of lead, cadmium and, more recently, silicon. But these materials have raised concerns over potential toxicity and environmental harm. As a result, scientists have begun to look for more benign compounds for making quantum dots.

Researchers have known for some time that carbon nanoparticles, due partly to their enormous surface area, have unusual chemical and physical properties quite different from their bulk form. Using nanoparticles produced from graphite, the researchers demonstrated that when these carbon nanoparticles are covered with special polymers, they glow brightly when exposed to light, behaving as tiny light bulbs. The dots glow continuously as long as a light source is present.
The scientists believe that this photoluminescence may be due to the presence of "pockets" or holes on the surface of the carbon dots that trap energy. The polymer coating acts as a "molecular band-aid," enabling light emission from the inside of the polymer casing, they say. Scientists believe that metal-based quantum dots emit light by a somewhat different mechanism.

The two-sided polymer coating also allows researchers to attach antibodies or other labeling materials to the carbon dot. This could lead to improved dyes for medical imaging and also the development of sensors that light up in the presence of a target, such as anthrax or even food-borne pathogens. In lab studies, the researchers successfully labeled anthrax-like spores with luminescent carbon dots, resulting in glowing spores that were easily viewed under a microscope

The development, which could help broaden the use of quantum dot technologies, is described in a research communications published online today by the Journal of the American Chemical Society. The paper will appear in the journal's June 7 print edition.

AIST develops method to mass produce carbon nanotubes

Japan's National Institute of Advanced Industrial Science and Technology, known as AIST, has developed a method to mass produce carbon nanotubes, raising output efficiency by 100-fold.
The method, reported recently at a symposium hosted by the New Energy and Industrial Technology Development Organization, will pave the way for the commercialization of carbon nanotubes.

Researchers at AIST's Research Center for Advanced Carbon Materials, led by Takeshi Saito, succeeded in raising the output of single-walled carbon nanotube, or SWNT, by improving a conventional synthesis method called direct injection pyrolytic synthesis.

Under the conventional method, a gas made up of carbon-containing materials, catalyst and reaction accelerator is pumped into a furnace to make SWNT. Saito and his colleagues adjusted the composition of the mixture and the temperature of the furnace. As a result, the purity of the SWNT produced was raised to above 97.5 percent from 50 percent, while the amount of structural defects was reduced to less than one-tenth. With the adjustments in the technology, the researchers also succeeded in adjusting the diameter of the SWNT by as little as 0.1 nanometers.
The diameter of SWNT ranges from 0.4 to 50 nanometers, and the length from one to several micrometers. One nanometer is one-billionth of a meter, and one micrometer is one-millionth of a meter.

The AIST team said its achievement is a major breakthrough in technologies to commercialize SWNT, adding that the AIST's SWNT- producing technology is the most advanced around the world. The commercialization of carbon nanotubes has been delayed because of the lack of technology for mass production.

New laser technique enables lower-temperature semiconductor processing

A team of researchers have achieved a long-sought scientific goal: using laser light to break specific molecular bonds. The process uses laser light, instead of heat, to strip hydrogen atoms from silicon surfaces, a key step in the manufacture of computer chips and solar cells.
The new technique was developed by Philip Cohen, at the University of Minnesota, working with Vanderbilt University researchers along with Zhenyu Zhang from Oak Ridge National Laboratory. The work is described in the May 19 issue of the journal Science.

"We live in the silicon age," said one of the authors. "The fact that we have figured out how to remove hydrogen with a laser raises the possibility that we will be able to grow silicon devices at very low temperatures, close to room temperature." Microelectronic devices are built from multiple layers of silicon. In order to keep silicon surfaces from oxidizing, semiconductor manufacturers routinely "passivate" them by exposing them to hydrogen atoms that attach to all the available silicon bonds. However, this means that the hydrogen atoms must be removed before new layers of silicon can be added. "Desorbing" the hydrogen is usually done by heating to high temperatures (800 C), which can create thermal defects in the chips and so reduce chip yields.

"One application that we intend to examine is the use of this technique to manufacture field effect transistors (FETs) that operate at speeds about 40 percent faster than ordinary transistors," said Cohen. According to Cohen, it should be possible to reduce the processing temperature of manufacturing FETs by 100 degrees Celsius, which should dramatically improve yields.

Because the silicon/hydrogen system has been intensively studied, the researchers knew the strength of the bond between the silicon and hydrogen atoms. The bonds between atoms act something like an atomic spring. Like tiny springs, they tend to vibrate at certain frequencies and are most likely to absorb light photons that vibrate at these frequencies. As a result, light tuned to these "resonant" frequencies can force the bond to break. When the researchers scanned the laser through the frequencies that they had calculated would resonate with the silicon-hydrogen bond, they found that the rate of hydrogen desorption peaked at an incident wavelength of 4.8 microns (1/6,250th of an inch). Prior theoretical work predicted that a substantial fraction of the hydrogen could be excited but that temperatures well above room temperature would be needed for an effective process. But once they got the setup right, the researchers found that the laser desorption process:

- Strips hydrogen from the silicon surface even at room temperature.
- Generates surprisingly little heat. In the infrared wavelengths used by the researchers, silicon is basically transparent.
- Exhibits a high degree of selectivity. With the hydrogen/deuterium mixture, the researchers demonstrated that they can remove large numbers of hydrogen atoms without detaching many of the deuterium atoms.

Selectivity of this kind could provide a way to control the growth of nanoscale structures with an unprecedented degree of precision, and it is this potential that most excites Cohen. "By selectively removing the hydrogen atoms from the ends of nanowires, we should be able to control and direct their growth, which currently is a random process," he said.

'Cloaked' carbon nanotubes become non-toxic

A way to cloak carbon nanotubes, making them both non-toxic and highly customisable, has been revealed. It marks a step towards using nanotubes in biological research and medicine.

Nanotubes are rolled up sheets of linked carbon atoms and are as little as 10 atoms wide. In the future they could act as tiny molecular sensors, detecting individual enzymes inside living cells, or could enable new medical treatments for diseases such as cancer.
But for reasons that remain unclear, bare nanotubes are toxic, triggering the death of cells that they touch. To deal with this problem, researchers at the University of California, Berkeley, US, created rod-shaped synthetic polymers that mimic molecules found naturally on the outer surface of the body's cells. They then attached these molecules to the nanotubes like pine needles on a twig.
This polymer coating prevented the nanotubes from damaging cells grown in the lab. They also provide a versatile way to customise the nanotubes.

The coating mimics biological molecules called mucins – a family of complex sugar molecules embedded in cells' membranes that help regulate how the cells interact with the rest of the body. By choosing to mimic a particular mucin, the research team led by Alex Zettl coaxed the treated nanotubes into bonding to the outside of their test cells.
Other ways to make nanotubes non-toxic exist, but they lack this ability to attach to specific targets.

But Chiu Lam, an expert on the toxicology of nanotubes at NASA's Johnson Space Center, says he wonders whether using nanotubes for medicinal applications makes sense, even with such a coating. "Even after modification, they have to be sure they will be eventually eliminated from the body," Lam points out. Bare nanotubes do not biodegrade naturally, and the liver and kidneys can't remove them, he says. So if this new coating wore off while the nanotubes were still inside a person's body, they would linger in the body's tissues and become toxic.
Zettl says that, by using coatings that mimic substances that the body knows how to expel, his group should be able to ensure that the nanotubes are eliminated from the body naturally. The coating that they tested adhered to the nanotubes for "several months", he says.

Journal reference: Journal of the American Chemical Society

Life Sciences

Potential New Treatment Strategy For Alzheimer's Disease And Other Brain And Spinal Cord Damage

A study led by researchers at the San Francisco VA Medical Center and the University of North Carolina, Chapel Hill has identified several new compounds that could play a role in preventing or treating Alzheimer's disease and other degenerative conditions of the nervous system.

NaNIn culture, the compounds bind with a receptor found in the brain and spinal cord called p75NTR. In the body, p75NTR is a binding site for molecules known as neurotrophins, which normally promote the growth and development of neurons and other brain cells but, according to other studies, can also kill them, depending on how and where they bind to a cell.
Evidence suggests neurotrophins may play a role in Alzheimer's disease and other brain diseases and conditions, says lead author Stephen M. Massa. In Alzheimer's disease, some of the brain cells that die - including neurons in the hippocampus, which plays an essential role in memory - express the p75NTR binding site, indicating they may be dying because neurotrophins are binding to them, says Massa.
When Dr. Rita Levi-Montalcini won the Nobel Prize for Medicine in 1986 for her discovery of neurotrophins, she remarked that the next critical milestone would be to develop pharmacological approaches that could achieve the actions of these potent proteins and make possible their potential application in the clinic. The present work seems to have attained this decades-long goal.

In further tests, the research team discovered that the compounds can also inhibit the death of oligodendrocytes, the cells in the central nervous system that form myelin, the insulating sheath surrounding nerve cells. Normally, oligodendrocytes die when exposed to proneurotrophins - precursor forms of neurotrophins that have been implicated as agents of tissue damage in multiple sclerosis, spinal cord injury and Alzheimer's disease.

The study appears in the May 17, 2006 issue of the Journal of Neuroscience.