Message from the future
By Helene Zampetakis MIS

If nanobots and skycars sound more like sci-fi than a sane view of the future, then you may need to reprogram your mindset. Helene Zampetakis reports on the technology that will shape our lives in the decades to come.

A trio of disruptive technologies will converge over the next five to 15 years to overtake our incumbent systems and create new competencies that will profoundly change the way we organise our lives and the way we do business.

The driving principles behind modern technology are running out of steam: it is becoming prohibitively costly to continue to shrink technology, while Moore's Law, which postulates the doubling of computer power every 18 months, is reaching its physical limits under current processes.

By 2015 we will be hard pressed to use today's techniques to make devices increasingly smaller and more powerful.

But research that is underway today is expected to usher in a new technological era. Dubbed 'embedded connectivity' by Bob Hayward, vice-president and research fellow at Gartner, it will draw strength from nanotechnology, sensors and wireless technology.

The embedded world of the future will harness the power of billions of microprocessors on a single device, wirelessly connected to others, that can read the environment and react accordingly. Scientists portray a future in which we attach these devices to our bodies to communicate, set them loose on our streets to do menial tasks, and embed them in the commonplace objects of our lives to address our daily requirements.

The underlying foundation for this new era of embedded connectivity is nanotechnology, which is based on the manipulation of molecules less than 100 nanometres in size. At one millionth the size of a millimetre or 1/100,000th the diameter of a human hair, and roughly five times the size of an atom, a nanometre (nm) is the measuring unit for the basic building block of the future. "Nanotechnology means that rather than taking a chunk of silicon and carving it down to size, we build from the bottom up by assembling single molecules and atoms," says Dr Terry Turney, director of CSIRO's nanotechnology centre.

Manipulating molecules in this way opens up such extraordinary possibilities that the US Government predicts nanotechnology will generate US$1 trillion in products worldwide by 2015.
**Electronic circuitry**
Research into these nanoscaled technologies is in progress now. Take the field of electronic circuitry, for example. Today, cutting-edge integrated circuits have been shrunk to 65nm in size to make space for more transistors and so increase performance.

In molecular computing, however, computer scientists are building circuits at the atomic level so they can harness the lightning-speed reactions or vast storage reserves that can be elicited from infinitesimal components.

IBM is experimenting with molecular self-assembly to build microchips using nanoparticles to improve circuit performance, and expects to be in pilot phase three to five years from now. Two years ago, it achieved terabyte storage on a single chip.

With similar visions for the future, Hewlett-Packard is building molecular-sized Atomic Resolution Storage products, which would encode one bit per atom and deliver 100 million times the information density of current hard disks.

By 2015, these advances will likely disrupt the entire semiconductor fabrication industry. By introducing new types of basic components to electronic computer circuitry, which measure no more than a few tens of nanometres across, these advances will deliver the potential to run massive parallel computing on devices the size of a 50 cent coin.

**Quantum information processing**
Even further out, quantum information processing (QIP) will dramatically improve the acquisition, transmission and processing of information to enable hugely complex functions, which will include factoring vast numbers in cryptographic applications or pattern matching.

The technology involves tapping into the processes by which atoms interact to create the properties of quantum computing.

"It will give us an order-of-magnitude jump from the fastest computer of that time - it will not be an evolutionary increase," says Gartner’s Hayward.

But these developments will also expose us to unimagined privacy, security and ethical challenges.

"By the time we comprehend the privacy risks, the horse will have bolted," says Hayward. "As for security, whereas it takes a month for a supercomputer to crunch a DES encrypted code today, it would take just a couple seconds [using QIP]. But maybe we’ll also get a corresponding advance in security algorithms."

Nanotechnology research is still in its early stages but the results are already filtering into our lives. Nanoparticles are the constituent components of advanced sunscreens today, while trials of Ambri biomedical testers that mimic cellular sensors are underway at Sydney’s Royal North Shore Hospital.

**Advanced materials**
Over the next five years, the development of nanoscaled sensors will allow intelligence to be built into many materials for multiple applications.

Take the field of advanced materials, in which structures are systematically synthesised to provide a precisely tailored set of properties. CSIRO’s Dr Turney says this work will give rise to applications such as intelligent textiles using nanoparticles, which will expand their weave on a hot summer’s day, or construction materials that change into ceramics in the presence of fire.

He describes a world that is five to 10 years away, which will be minutely responsive to our needs. Combined with sensors, advanced materials will be able to react to their environment in new ways. For example, advanced materials will allow food producers to embed intelligence into packaging on products by implanting biosensors that respond to changes in the contents,
"Within 10 years you'll be able to walk into a supermarket and pick up a salami and look at a biosensor display unit on the package to get data such as whether it contains gluten or if it's developed salmonella."

Sensors will be pervasive in the embedded environment of the future, says Dr Turney. A key to this advance is that the next generation of miniaturised sensors will have very low power requirements.

**Power scavengers**

Now the size of a match head, sensors are being scaled down even further to hold more power. These sensors could be fuelled by 'power scavengers' that harvest energy from everyday forms of energy, such as the simple act of walking, and convert them into voltage.

Once harvested, the energy may be stored in micro-supercapacitors, which are being engineered to provide thousands of times the volume of electricity of standard capacitors. Industry specialists say once these elements become workable, organisations will rapidly set up complex webs of wireless networks.

IBM's business consulting services wireless leader, Will Duckworth, says in the next 10 years wireless machine-to-machine networks will generate 'sense and respond' ecosystems using WiMAX as their backbone and Radio Frequency Identification (RFID) and other methods of surveillance for remote tracking.

"These systems typically produce a lot more data than a human," he says, citing business drivers such as pollution monitoring, inventory management and container tracking.

John Murray, director of venture capital firm Australian Technology Group, anticipates webs of intelligent wireless networks "powered by very cheap devices that run on low power and capture data as it's happening, and feed that back into information systems."

"They will allow companies to respond in real time and to automate their responses in the supply chain and in their business ecosystems. It's all about connecting the sensory organs of the business to the outside world and feeding back intelligence to automatically respond in real time without human intervention," says Murray.

Further automation will come by adding robotics to this equation.

**Robotics**

It will be at least 20 years before we see microscopic 'nanobots', the much-hyped molecular manufacturing systems that have generated sci-fi like fears of mutating swarms running amok. But miniature robots are in fact under serious investigation.

In 2000, for example, MIT's Bioinstrumentation Laboratory unveiled the Nanowalker, a sugar-cube sized prototype of the first autonomous nanorobot. The Nanowalker is able to move with great precision at a speed of about 4,000 steps a second and communicate wirelessly to a central computer.

Nanorobots will eventually construct materials atom by atom to create products that do anything from surveillance to in vitro navigation.

Larger robots will be with us sooner than that.

"Robots will be fairly prevalent 10 years from now. We'll see them in offices and hospitals and shopping centres," says Dr Peter Corke, autonomous systems team leader at CSIRO.

Currently robots operate in controlled environments designed around them, such as car assembly plants, but the next generation of machines will be designed to function in a less structured world and to cope with unexpected changes to their environment.
Robotics research today centres around embedding these devices with fuzzy logic skills using sensors that will allow them to perceive and respond. Dr Corke says we could expect to see this class of machine delivering mail or medication or stacking store shelves at low cost to replace human labour in five to 10 years from now. Larger versions could be used down mines; and indeed this research is principally funded by the mining industry, along with organisations interested in flying robots that can inspect assets such as power lines.

**Transportation technologies**

On an even larger scale, a number of organisations globally are working both separately and collaboratively to develop the next set of transportation technologies.

Among them, NASA, Boeing and small companies such as Moller International, are working on developing skycars for personal use.

These will let us travel "when and where but especially how we wish", according to Mark Moore, personal air vehicle sector manager for NASA's Vehicle Systems Program.

"We’re working to assist in making easy-to-operate, quiet, and affordable small aircraft a mobility choice for future transportation."

Moore says there are currently many diverse research efforts ongoing across the world. "Each organisation is taking on portions of the technology set that they think are important."

NASA's area of focus is a skycar (or personal air vehicle - PAV) designed not for getting about the city, but for travelling at high speeds for distances of between 160kms to 800kms. That would allow people to live in regional areas and commute into urban airfields for work.

Over the next decade Moore expects to see flying cars priced at less than US$100,000 using automated functionality based on NASA's EquiPT (Easy-to-use, quiet Personal Transportation) technology set.

Moore says an obstacle to PAVs has been the intensity of training required to fly them, so automation is critical. The goal is to have the vehicle controlled by a computerised brain that senses and responds to weather conditions or other crafts in the vicinity, and compensates for technical failures.

NASA is also developing a network of highways in the sky under its Small Aircraft Transportation System that controls air traffic using global positioning system (GPS) and a phalanx of broadband satellites to monitor the exact location of every vehicle in flight.

Although a single vehicle for all transport purposes is more than 25 years away, prototype skycars are already with us. Moller is accepting deposits to secure one of its M400 Skycars, which is designed for vertical takeoff and landing. Delivery is promised after a full test flight, which is expected to take place early in 2005. First owners will pay US$995,000 for a four-passenger skycar, which will run on a fuel such as alcohol, petrol or recycled cooking oil.

**Videoconferencing**

But physically moving from one place to another may become needless with the next generation of videoconferencing tools.

The synergy of vastly increased bandwidth, three-dimensional video projection and interactive holography systems is expected to change the way we collectively communicate, according to James Anderson, country manager of Polycom.

Videophones as a standard business tool are a decade away but it will be more like 20 years before research from bodies such as MIT’s Spatial Imaging Group or 3D visualisation company, Actuality Systems, yields practicable holographic videoconferencing. By then, however, "we’ll be looking at life-size holograms in 3D that can move around the room in full motion", says Anderson.
You will have business managers dispersed globally talking as if they are face to face.

But in half that time, people will be able to dial into conferences from mobile phones and project holograms of themselves or use headgear as visualisation tools for collaborative work, says Anderson.

Venture capitalists such as Michael Panaccio, a founder of Starfish Ventures, points out that many of these future scenarios are not based on disruptive technologies but on incremental advances in existing systems.

"They will be mind-boggling from today's perspective but they will be based on the convergence of technologies that have their roots in today."

**Business technology on the move**

Below are outlined the top five expected changes in business technology in next five to 10 years.

- **Service oriented architecture**: Software will become a service. Web services applications will automatically be directed to other application services through standard interfaces, creating system-to-system communication.

- **Utility computing**: Enterprises will increasingly opt for a pay-as-you-go model of technology. They will pay fees on a transaction basis for functions such as storage, processing and managed security.

- **Virtualisation**: Advances in virtualisation and policy based management tools will help organisations manage multiple devices from a single product. These tools will be policy based so that management can be automated.

- **Wireless mobility**: Between 10 per cent and 15 per cent of enterprises use wireless technology today but that figure will be closer to 75 per cent in three years' time, says Gartner's Bob Hayward. Wireless devices will become cheaper, handle greater bandwidth and consume less battery power, especially because of advances in screen technology.

- **Metadata tools**: The average enterprise captures 30 per cent more data every year from wired and wireless activities, says Hayward. Enterprises will be leveraging this surge with business intelligence tools that probe and analyse these vast repositories to extract more information about the data.

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