Contents

Plugging in, at last

Communications: After years of delay, the provision of internet access over power lines is taking off—though not for the reasons you might expect

THIS is "a banner day…a historically significant day for communications," declared Michael Powell in mid-October. The chairman of America's Federal Communications Commission (FCC) was enthusing about the prospects of a novel way for customers to receive ultra-fast broadband internet service in their homes: via the stodgy old power grid.

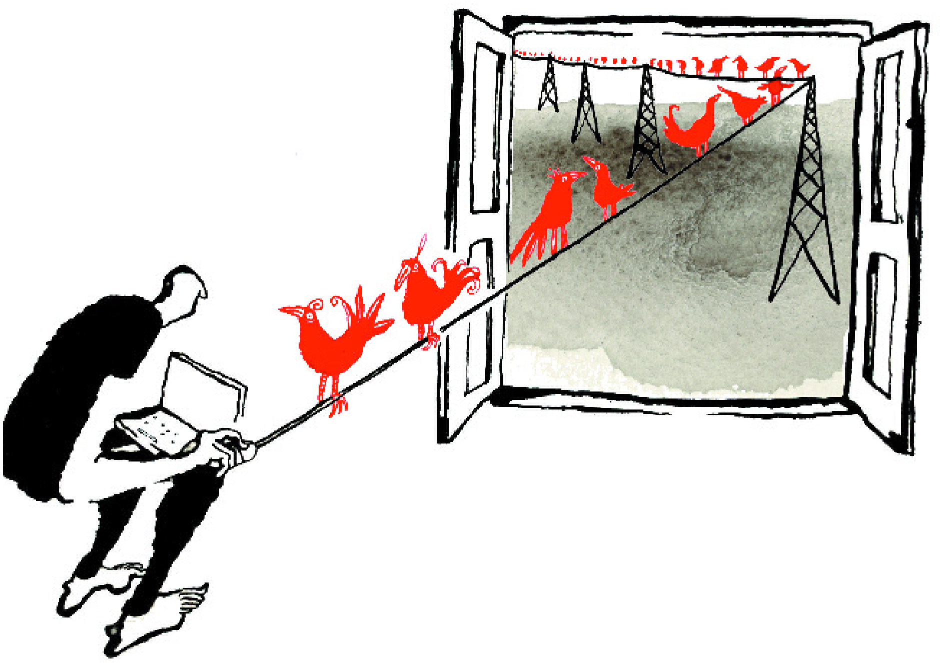
The idea of using the power grid as a communications network—known as "broadband over power lines" (BPL) in America and "power-line communications" (PLC) in Europe—has been around for ages, but is at last being implemented. Mr Powell made his comments at a meeting where the FCC gave its formal blessing to BPL. Crucially, the agency ruled that utilities that follow certain rules (chiefly concerning radio interference) would be given a wide berth to operate as "unlicensed" entities, unencumbered by America's baffling telecoms rules.

Why bother with BPL? The FCC is keen because it will bring into the broadband market a third group of competitors, after telephone firms, which use supercharged phone lines (digital subscriber lines, or DSL) to deliver broadband, and cable-TV operators, which use their cables for the same purpose. Another competing technology should lower prices. BPL may also further the FCC's goal of universal broadband service. The use of power lines means almost everyone in the rich world should be able to receive broadband service through this approach. That is not true for cable, which does not have universal coverage. Utilities are already eyeing new markets in rural areas.

William Berkman of Current Communications, a leading BPL operator, argues that the technology offers several advantages for customers, too. Connection speed is not dependent on the distance from a telephone exchange (as with DSL) or on the number of customers online at once (as with cable). BPL, unlike its rivals, offers uploads at the same speed as downloads. And, says Mr Berkman, it will ultimately offer far more capacity than today's cable networks. "This is a bet on bandwidth," he says. "You want video and TiVo over the internet? You'll get it."

Yet old hands remain sceptical, for BPL is hardly a new technology. Indeed, engineers tried to make it work for many years, but failed due to snags in the "last mile": in particular, the final "step-down" power transformer, at the point where the power from the grid enters a home or office, interfered with the flow of data.

But two new ways have been devised to solve this problem. One is to route around the step-down transformer using ▸▸

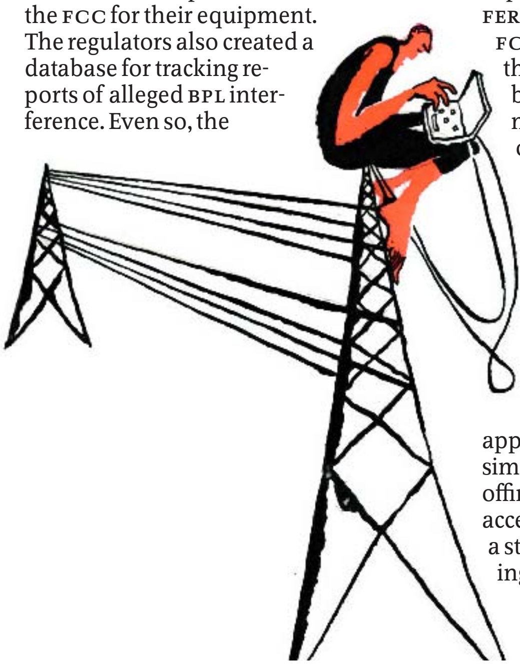


wireless technology. The transformer is often on a utility pole outside the customer's premises, so it need only be a short hop to a wireless receiver indoors. The other approach routes the data signal around the transformer and then feeds it back into the domestic electricity supply. A special modem plugged into an electrical outlet then deciphers the signal. This approach also allows domestic electrical wiring to double as a home network.

Despite these steps forward, several problems may yet derail BPL. One is security. Some worry that it may be too easy to pilfer your neighbour's e-mails by intercepting the signal from the wireless transmitter sitting on the pole between your houses. But early field trials—and there have been several dozen such trials, in America, Canada and Europe—suggest that this worry is misplaced. The most advanced trial is taking place in Cincinnati, Ohio, where some 15,000 customers now receive BPL on commercial terms.

Jim Rogers, the boss of Cinergy, the trail-blazing local utility, points to the second potential snag facing BPL: the stodginess of utilities. Traditionally, the sector has not been very innovative, but in this case caution might be justified. Mr Rogers notes that risky broadband investments would need to be made today out of unregulated profits—but with no guarantee that regulators would not claw back BPL profits tomorrow as "regulated" earnings.

Another concern is radio interference. Ham-radio operators have complained vociferously that BPL signals are "bleeding" from power lines and spoiling their hobby. The emergency services use some frequencies that may be affected too. So the FCC's October ruling establishes "excluded frequency bands" for aeronautical communications and public safety. Firms that manufacture BPL gear must "notch out" emissions within those bands, and win pre-certification from the FCC for their equipment. The regulators also created a database for tracking reports of alleged BPL interference. Even so, the ham-radio operators were not satisfied. Yet they claim that the technology will fail to take off anyway. Their trade association claims that other broadband technologies, such as Wi-Fi and new fibre-optics networks, will "leave BPL in the footnotes of technology along with the eight-track tape player."



Perhaps. But there is reason to believe that BPL might finally start to live up to its potential, thanks to an unexpected ace in the hole that DSL and cable do not have: the big blackouts that hit North America, London and Italy last summer. Those fiascos were the result not of a shortage of generating capacity, but rather of the failings of an antiquated grid. Today's electrical system is a creaking relic lacking the sophisticated command-and-control tools necessary to ensure reliability. As last summer's outage in America showed, local operators often do not know when or where power has gone out on their system.

BPL could change all of that. A beautiful side benefit of the technology is that data-enabling their power networks will let utilities monitor what is happening on their power grids in real time, down to local substations. The technology could also allow them to read power and water meters without entering customers' premises. Mr Rogers of Cinergy notes that it might also allow utilities to manage peak loads by, for example, turning down your residential air conditioner remotely while you are at the office, in return for a lower tariff.

"The reliability aspects are unbelievable!" gushed Nora Brownell in October as she toured a utility in Virginia that has implemented BPL. Her view matters, for she is a commissioner on the Federal Energy Regulatory Commission (FERC), the country's top regulator of power utilities. In a telling and unorthodox show of support for the new technology, the FERC's commissioners turned up at the FCC meeting at which BPL was given the green light. Pat Wood, the FERC's boss, even offered this forecast: "It's my hope that a year from now boards of directors and shareholders and customers are all asking utilities, 'Why aren't you in BPL?'"

It finally looks as though BPL's day has come. The happy collision of Mr Powell's desire for broadband competition and Mr Wood's dream of grid reliability is spurring on BPL technology. Revealingly, European officials, who have in the past been cautious about PLC technology, applauded the FCC's decision in October: similar pan-European rules may be in the offing. The result could be better internet access for customers—and, just possibly, a step towards the intelligent, self-healing power grid of tomorrow. ■

A grid by any other name

Grid computing: It might be the next big thing in computing. But for now, grid computing's biggest problem is that nobody can agree what it is

WHEN is a grid not a grid? It depends whom you ask. According to many in the computer industry, grid computing—which roughly means the harnessing of the collective processing power of many computers in different places—is here today, and is already widespread. Yet according to others, grid computing, while promising, is still years away from becoming a reality. Who is right?

The problem is that "grid" has been co-opted as a buzzword and applied to a number of entirely different things. The term "grid computing" was originally coined by Ian Foster of America's Argonne National Laboratory in the late 1990s. He meant to draw an analogy between the supply of computing power and the supply of electricity, which is delivered along a wire, when you need it and with no need to worry about where it came from.

In 2002, Dr Foster drew up his own three-part definition of grid computing. A grid, he proposed, should co-ordinate computing resources that are not centrally controlled, rely on open standards, and provide more reliability than stand-alone machines. Alas for Dr Foster, his checklist immediately raised hackles within the computer industry, since much existing "grid computing" software fails to meet these criteria. Linking many small computers together to create a more powerful machine, for example, is not new, and is usually called clustering. For marketing purposes, however, some firms like to call it grid instead.

Similarly, grid is often confused—sometimes deliberately, for marketing reasons—with equally nebulous terms such as utility computing, on-demand computing, autonomic computing and data-centre virtualisation. Behind all this terminology is the idea of continuously and automatically adjusting the configuration of a corporate data-centre to meet the demands made on it. But Andrew Chien, a grid pioneer at the University of California at San Diego, notes that though useful, such approaches generally eschew the harder part of the grid vision, which requires automated sharing of computing resources between different organisations, not just within one firm.

A well-known example of the sharing

of computing resources across the internet is SETI@home, in which over half a million people help to sift radio-telescope readings for evidence of extra-terrestrial life using a glorified screen-saver running on their PCs. Other similar projects, such as IBM's new World Community Grid, conduct medical research. But David Anderson, the director of SETI@home, rejects the grid label, preferring the term "public resource computing". Others call it "internet computing" or "cycle scavenging". While it is grid-like in some respects, this approach is very task-specific and is centrally controlled—so it is not truly grid.

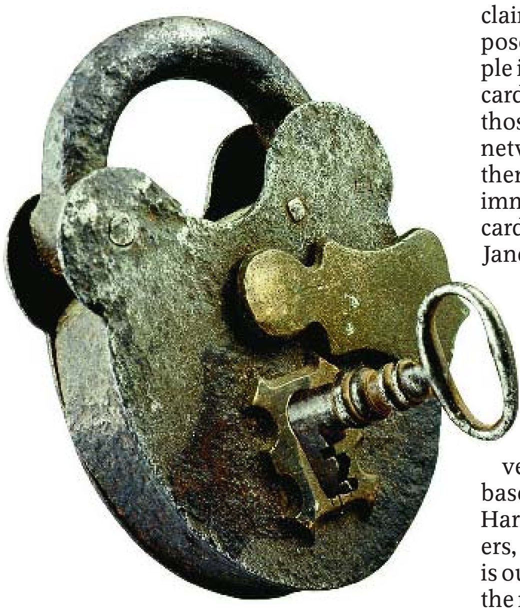
Some firms, such as United Devices, sell proprietary software for cycle scavenging within a single company. Idle PCs can, for example, run drug-design software in a pharmaceuticals company or evaluate a derivatives portfolio for a financial-services firm. Early adopters of this technology claim impressive benefits. Yet since all the resources are controlled by a single organisation, purists argue that this is at best an "intragrid", just as an intranet is a private, internal version of the internet.

What of those deliberately decentralised systems, peer-to-peer file-sharing networks? Some of them, at least, operate using open standards, and they are certainly robust: repeated attempts to close them down have failed (see pages 29-30). But they do not count as grid computing either, since they are mostly storage and distribution systems, and do not perform general purpose data-processing.

Grid computing is not entirely fictional, however: scientists have been building grids on a national or even global scale for several years. A good example is the LHC Computing Grid, which links large clusters and storage systems in 87 computer centres around the world, for the benefit of particle physicists. Another example is TeraGrid, an American effort to link nine large supercomputing centres for scientific use. Even within the academic arena, though, convergence towards common standards is slow, partly because each grid project tends to reinvent the wheel. To tackle this problem, the European Union launched a major initiative called EGEE this year to provide a common grid infrastructure for scientists; America has a similar initiative.

The hope is that such projects will provide the first glimpse of "the grid", a single global computing grid that will do for data processing what the world wide web did for online publishing. Wolfgang Gentzsch, a former grid guru at Sun Microsystems who is now director of MCNC, North Carolina's statewide grid initiative, says the term "grid" really refers to this ultimate goal, towards which today's systems are merely stepping stones. But it would, he admits, be more accurate to refer to them as "grid-like" or using "grid technology".

Constructing a single, global grid will mean solving difficult security, privacy and billing problems. Scientists have a tradition of sharing their results and resources, but others do not. Yet the hurdles are not so much technological as political, economic and terminological. The dream of a single grid, akin to the web in its simplicity and pervasiveness, still seems a long way off—as does agreement about what "grid" really means. ■



Security through viral propagation

Security technology: A new kind of door lock combines low-tech and high-tech approaches to enhancing security—but is it really safer?

IN THE security industry today, one part is decidedly sexier than the other. The sexy part deals with digital security, which includes everything from fighting computer viruses and fending off malicious hackers to controlling which employees have access to which systems. All of this has overshadowed the less glamorous part of the industry, which deals with physical security—in essence, door locks and that sort of thing. At parties, the digital guys come across as cutting-edge, whereas the door-lock guys soon have to admit that their last truly stunning innovation, the pin-tumbler lock, was devised in ancient Egypt but then got lost for 4,000 years until Linus Yale, an American inventor, rediscovered it. And even that was a century and a half ago.

Assa Abloy, a Swedish company that is the world's largest lockmaker, wants to change that. So it has teamed up with CoreStreet, a software company based in Cambridge, Massachusetts, to merge digital and physical security into a single system. The idea is that the same computer database that gives employees of a firm or government access privileges online also opens (or closes) doors for them. The twist, however, is that the doors need not have a permanent, hard-wired connection to the central computer.

Today, the only way to allow door locks to authenticate ("Are you who you claim to be?") and validate ("Are you supposed to be entering at this hour?") people in real time is to install electronic card-readers on doors, and then hook those readers up to a secure computer network. If an employee named Jane then gets fired, the central database will immediately inform all the connected card-readers, which will stop accepting Jane's key card.

The problem is that this sort of network is very expensive. An electronic lock costs between $3,000 and $5,000, 80% of which is the cost of network wiring, says Phil Libin of CoreStreet. Wiring up all the locks of, say, a nuclear power plant, university campus, airport, or military base therefore becomes extremely costly. Hard-wiring the doors of trucks, containers, aeroplanes and other moving things is out of the question. This is why, even in the most secure settings, at most 3% of locks tend to be connected.

CoreStreet's solution is "to make the cards themselves the network", explains Mr Libin. There is still one central access list that says who is allowed to open what, and it is regularly sent out to the 3% of locks that are connected. The cunning part is how the list is propagated to other, unconnected locks: by the users themselves. Whenever an employee swipes his card through a connected lock, the list is copied, in encrypted form, on to the card. As he then walks through unconnected doors, the card transfers the latest copy of the list on to their locks, replacing their older versions. These locks in turn pass the new list on to any other cards passing through, and so on.

As long as people keep moving through doors, says Mr Libin, the freshest list of privileges spreads by "viral propagation". The trick is to position the few connected locks carefully, to ensure that updates to the list spread within minutes to all the other doors. That way, Jane, having been fired, will find that her card no longer works. The new "intelligent" locks from Assa Abloy and CoreStreet that do all this cost about $1,000 each. ▸▸

Not everyone is convinced, however. Marc Tobias, an expert on locks who has literally written the book on the subject—all two volumes and 1,400 pages of it—has heard grand claims being made about new kinds of lock before. He has been picking locks since he was 15, though he has not yet picked one of the new Assa Abloy locks (which have so far been supplied to ten trial customers). But, he says, "I'd be really paranoid about this until it has been thoroughly vetted." As Bruce Schneier, a security expert, likes to point out, security is like a chain, and is only as strong as its weakest link. The new system's security depends on protecting both the encrypted access list and the network that links up the connected doors. Making physical locks as secure as computer networks, in other words, means precisely that. ■

The evolution of the photofit

Security technology: A new type of computerised photofit system takes a novel evolutionary approach to generating images of suspects

IF YOU have ever tried to describe someone's face in detail, you will understand why the "photofit" composite images used by the police look so dodgy. In recent years, computerised "E-Fit" systems have helped improve the accuracy of these images by allowing witnesses to choose from a wider range of facial features. But researchers at the University of Stirling in Scotland found that, despite these improvements, people still have a hard time constructing recognisable faces—especially if there is a delay of more than a few hours between seeing the face and generating the composite.

The problem is that people tend to recognise faces as whole entities, rather than as separate features. So picking from a range of eyes, noses and mouths is not necessarily the most suitable approach, says Charlie Frowd, a psychologist at the University of Stirling. Next year, however, British police are expected to begin trials of a new computerised system, called EvoFIT, developed by Dr Frowd and his colleague Peter Hancock. It uses an evolutionary approach, known as a genetic algorithm, to "evolve" faces rather than piece them together.

The process is entirely non-verbal and takes a fraction of the normal time, claims Dr Frowd. A witness is shown an array of 60 different faces with random features. Having studied them closely, the witness is asked to choose the six images that most closely resemble the person they are trying to describe. These six are then used to generate another set of 60, by switching features between some of the images and by making random changes to others. The witness is then asked to repeat the task, whereupon a new batch of faces is generated, and so on. In evolutionary terms, this process is known as "genetic crossover and mutation", and is a powerful way to search a large number of possibilities for a particular solution. By allowing the user to steer the selection process, the program is able to generate a good likeness for the original face after just a few cycles.

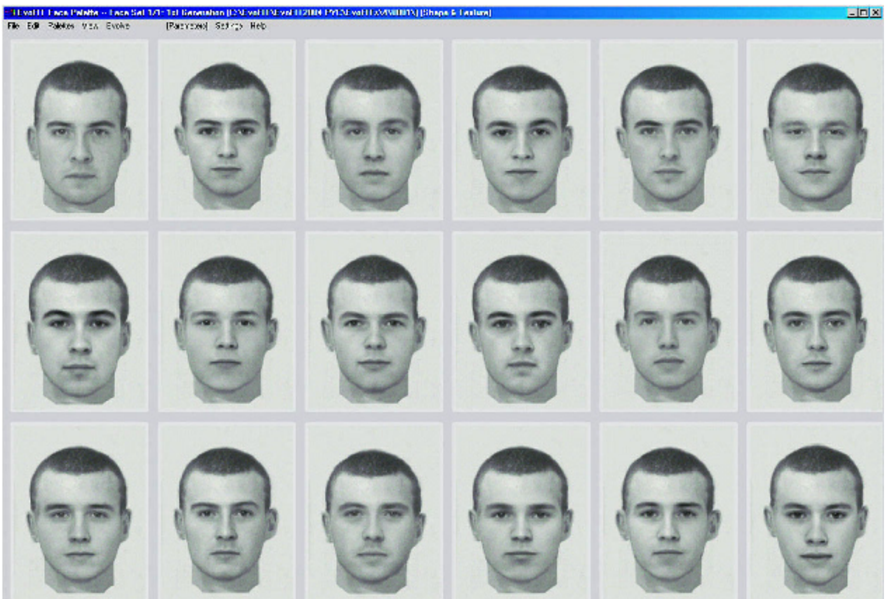
In one of its early versions, EvoFIT was used by police in Northamptonshire who were trying to catch a violent attacker. The attacker was never caught, but the senior investigating officer, Superintendent Paul Spick, says the witness involved found the new software much quicker and easier to use than traditional E-Fit systems. It was also more accurate: the final image caused the witness visible distress when displayed. A further important advantage of EvoFIT over traditional composites is that an image can be generated even if the witness can only provide a sketchy verbal description.

The researchers have since made a number of further improvements to their system and are now in the process of commercialising it in partnership with ABM, a British firm which supplies police forces with PROfit, one of the leading computerised composite systems. The images are more realistic, and the system can generate three-quarter angle views of the face, which are easier to distinguish than direct frontal views, says Dr Frowd.

His team has also found that by combining the images generated by different witnesses, or even from a single witness, it is possible to get an even better likeness. This could be particularly useful when multiple witnesses come forward and the police are unsure which of the images they produce is the most accurate. Another improvement has come from changing the image-selection process. In the latest version, witnesses are given a selection of face shapes to choose from before facial features are added. This makes it less likely that the correct facial features will be rejected simply because they are on the wrong-shaped face.

These modifications appear to make all the difference. In recent experiments, Dr Frowd and Dr Hancock compared EvoFIT with the computerised systems currently in use by asking volunteers to construct an image of a face two days after seeing it, and then showing the resulting image to people who were familiar with the person depicted. With traditional composites, the person was correctly identified about 4% of the time; the figure rose to 25% with EvoFIT images.

Next year ABM will perform in-house evaluations of the system and will then team up with police forces for further trials. Although things look promising so far, two things in particular need further testing, says Leslie Bowie, ABM's director of research. Do the EvoFIT images distract witnesses or contaminate their memories of the face they are trying to recall? And while EvoFIT has performed well in the calm conditions of the laboratory, how will it cope with real-life witnesses, who are often traumatised by their experiences? If it can address these two questions, EvoFIT could be the next step in the evolution of the photofit. ■



Not the usual suspects

The future of crowd control

Security technology: Should a more high-tech approach to keeping the peace, using sounds, shocks and stinks, replace existing methods?

WHEN faced with rowdy protesters, police forces have a number of tools at their disposal with which to disperse crowds and quell violence, including batons, shields, rubber bullets and water cannons. But these antiquated devices are crude and rely on brute force, which can lead to further violence and can, in some situations, prove lethal. A number of new crowd-control technologies take a different approach, employing sounds, shocks and stinks to disperse or incapacitate protesters. Such "non-lethal weapons" (NLWS) have been talked about for years, but they are now attracting much more interest, for a simple reason: Iraq.

Between 1997 and 2003, America's Joint Non-Lethal Weapons Programme, which co-ordinates the development of NLWS for the American military, had an annual budget of around $22m. In 2004, it was increased to $43.3m. The extra funding reflects the growing need, in Iraq in particular, for ways to control crowds while causing as little harm as possible.

There are several ways to do this. Earlier this year, American soldiers in Iraq were equipped with a Long Range Acoustic Device (LRAD) to use in western Iraq. It is a sort of mega-megaphone, able to blast sounds (such as crowd-dispersal instructions in Arabic) in a narrow beam and with great clarity at a deafening 150 decibels. The LRAD can also make a deafening screeching noise, like a fire alarm. This sound can incapacitate anyone within 300 metres by giving them an instant headache. According to Carl Gruenler of American Technology Corporation, the San Diego firm that makes the LRAD, "you definitely don't want to be there" within 100 metres of the noise. The device is intended to be used in short bursts at a distance of 300 metres, since longer exposures could lead to permanent hearing loss. It can also be used to flush people out of buildings, and has been deployed on American warships, to warn off small craft that come too close.

Where the LRAD targets hearing, a weapon that zaps the skin debilitates via the sense of touch. The United States Air Force has developed a microwave weapon, called "active denial technology", that would incapacitate crowds in this way. Microwaves are a form of electromagnetic radiation, like visible light or radio waves. If strong enough, the radiation can penetrate clothing and cause water molecules just below the surface of the skin to vibrate. These vibrating molecules heat up and create a burning sensation, akin to touching a hot light bulb.

There's one—set for stun

The microwaves are emitted in a tight beam that can be swept across a crowd or directed at specific individuals. Tests on volunteers, the air force claims, have shown no long-term effects other than tenderness caused by repeated exposure; of the $51m spent on developing the system so far, $9m has been devoted to evaluating its effect on victims. The system will be tested on the ground, mounted on Humvee armoured vehicles, during 2005, and the air force plans to award a $22m contract to develop technology to enable it to be used from the air.

Not all NLWS, however, depend on high technology. Taking a rather more old-fashioned approach is the "tactical malodorant ball"—a fancy name for what is really just a small, spherical stink bomb made by Paraklese Technologies, a firm based in Indiana that supplies law-enforcement agencies. Made of sterilised (but unspecified) animal faeces encased in a thin, gelatinous shell, it is fired from a rifle similar to a paintball gun. On impact, it leaves a powerful stench on an individual that strongly offends anyone standing nearby. The idea, says Dan Fosnight of Paraklese, is to isolate individuals who are instigating violence in crowds, in order to keep those around them safe.

It is not only human-rights activists and conspiracy theorists who regard NLWS with suspicion. Without rigorous, peer-reviewed research into the effects of all of these devices on people, it is impossible to be sure that they are any safer than batons and rubber bullets. The term "non-lethal" is something of a misnomer, since weapons described as such do not have to pass any specific test to demonstrate their non-lethal nature, and nearly all NLWS can kill if used in a certain manner. Even America's Joint Non-Lethal Weapons Programme defines NLWS as "weapons that are explicitly designed and primarily employed so as to incapacitate personnel…while minimising fatalities, permanent injury to personnel, and undesired damage to property." Minimising fatalities is not the same as preventing them altogether.

Andrew Mazzara of the Institute for Non-Lethal Defence Technologies, a research centre at the University of Pennsylvania, is conducting a rigorous evaluation of NLWS. As well as evaluating the physical effects of NLWS and determining what training is needed by their users, his institute is examining what tactics work best in particular crowd-control situations. The researchers are already assessing several NLWS, including the LRAD. Indeed, it is only now, months after it was deployed in Iraq, that the LRAD is being scientifically scrutinised by a body other than the company that sells it. But at least the claims that have long been made about NLWS are at last being put to the test. ■

Good vibrations

Consumer electronics: A French firm has found a way to turn dumb surfaces, from walls to table-tops, into interfaces to electronic devices

IMAGINE being able to tap anywhere on a wall to turn the lights on and off, or to change radio stations in the dining room simply by knocking on the table. Or how about dialling a phone number in the shower by tapping numbers on the glass door? Many things are powered by electricity and controlled by computer chips, but they co-exist with other items that are nothing but dumb, inanimate objects. A French firm believes a marriage is in order, and has developed a way to make hard surfaces such as walls, windows and table-tops into controls for consumer electronics, computers, household appliances and lighting, among other things.

"Our goal is to extend interactivity to all objects, to make everything smart," says Hubert Cospain of Sensitive Object, from the firm's temporary office in a com- ▸▸

plex of French university science labs on Paris's Left Bank, beside the building where Pierre and Marie Curie experimented with uranium. If his firm's invention can make the leap from laboratory to living room, it could integrate technology far more smoothly into the household environment—and even reduce the number of remote controls that are proliferating on sofas and coffee-tables.

The system, developed by Ros Kiri Ing of the University of Paris 7, works using sound. When a surface is hit, it vibrates, producing a characteristic combination of sound waves as unique as a fingerprint. Tap the surface again, an inch away, and a slightly different sound results. Two sensitive microphones pick up these sounds and turn them into electrical signals. Though the two sounds are indistinguishable to the human ear, they can be told apart using signal-processing software. Sensitive Object has patents both awarded and pending for this process, called "time reversal acoustics". It is not affected by background noise, since the sensors pick up the sound waves that propagate through the surface when struck, not the ambient noise in the room.

Some fine-tuning is required, however: this correspondent's attempt to turn on the lights in a room by tapping a special area on the wall required a half-dozen hits before it worked. But if the technology can be made suitably robust, it could serve many purposes. Using sound waves to distinguish between taps in different places could be used, the firm believes, in fields from oceanography to health care. The technique is well suited to situations, such as on board a ship, where water and electricity need to be kept apart. It could also provide a virtual PC keyboard in an operating theatre which could be wiped clean like any other surface. Mr Cospain even sees it being used for control panels in cars and planes, instead of heavy, complex bundles of wires. Initially, the firm is focusing on light switches, "virtual keyboards", and touch-enabling computer monitors, which the firm reckons it can do for around $10, or one-tenth of the price of existing technologies.

In September, the firm received €2m ($2.6m) from Sofinnova Partners, a French venture-capital fund, which it plans to use for further research and development, to secure patent protection, and to chase customers. Its plan is to license the technology to other firms who will incorporate it into their products. So when can we expect a pianist to perform using a blank surface as a substitute for the 88 keys of a piano? Today, the technology is only able to recognise two simultaneous taps, not enough for a basic three-note chord. "But," concedes Mr Cospain, "we're not too far away." ■

Not quite out of this world

Telecommunications: After years of hype, a new, cheaper way to blanket cities with wireless coverage may finally be about to get off the ground

THE recent success of Burt Rutan's *SpaceShipOne*, the first private spacecraft, has brought commercial space travel a step closer. Virgin Galactic, Richard Branson's new space-tourism company, which has licensed Mr Rutan's technology, already has £800m ($1.5 billion)-worth of ticket reservations, though flights will not begin until 2007. But as the fledgling space-tourism industry lifts off, another more mature space business could be heading for a fall. The communications-satellite industry, arguably the only space industry that actually makes any money, may find itself usurped by an unlikely technology that is a lot more down to earth.

Next month Sanswire Networks, a company based in Atlanta, Georgia, is planning to launch the first airship satellite, or "stratellite". Floating in the stratosphere at an altitude of about 20km (13 miles), the airship will behave just like a geostationary satellite, hovering over a particular spot and relaying radio signals to and from the ground. Such airships will, however, be much cheaper to launch and maintain than satellites—and can do things that satellites cannot.

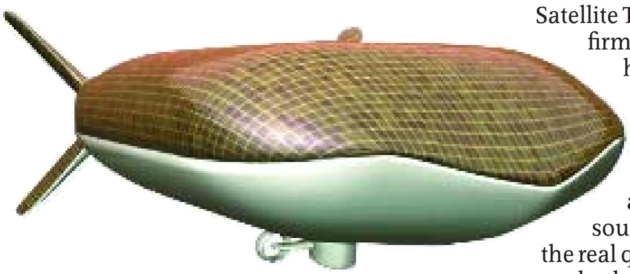
Each 75-metre-long airship will be controlled autonomously, and will contain nearly 37,000 cubic metres of helium to keep it and its 1.4-tonne payload aloft, says Michael Molen, Sanswire's chief executive. At such high altitude, above the jet stream, the reduced air density means that the wind will be about 20 times weaker than at ground level, enabling the airship's solar-powered electric motors to keep it stationary with very little effort. The craft's aerodynamic shape not only reduces drag but also generates lift when facing into the wind, says Mr Molen.

Like satellites, these airships will be able to provide wide-area mobile-telephone coverage, paging and other communications services. The company is most excited by the prospect of being able to provide wireless broadband coverage, akin to Wi-Fi, over large areas. A single airship could, says Mr Molen, potentially provide coverage over an area of nearly 800,000 square kilometres, or about the size of Texas. It should thus be possible to create "hotzones" of coverage encapsulating entire cities and their surrounding countryside, rather than the smaller "hotspots" of Wi-Fi coverage found in airports and coffee shops.

Standard Wi-Fi technology is, however, intended only for short-range communications. Beaming signals to and from an airship requires a special antenna. But the stratellite could be used to provide a high-speed connection to an access point for a home or office, which could then connect to nearby devices using Wi-Fi. The stratellite service would, in short, offer an alternative to cable and digital subscriber-line (DSL) broadband links. It would also be useful in countries with little or no network infrastructure, notes Ron Hochstetler, the chairman of the Airship Working Group at America's Federal Aviation Administration.

Airships are, he says, the only aviation technology that has not been fully exploited, which is why America's military is evaluating them for heavy-lifting and transport duties. They could have other military uses, too: in 2006, Lockheed Martin is due to position a prototype airship over the city of Akron, Ohio, once the centre of Goodyear's blimp operation, as part of an experimental missile-defence system. It will have communication and sensing capabilities, but no weaponry on board. It may seem low-tech compared with the armed satellites proposed in the 1980s by Ronald Reagan, but airships could do some of the work of satellites at much lower cost.

For even if you ignore the development costs of the rocket and the satellite itself, it still costs around $7,500 for every kilogram of satellite payload launched into low-earth orbit. For a typical satellite that means at least $40m. The satellite then typically has a lifetime of between five and seven years, after which it runs out of fuel and must be decommissioned and placed in a junk orbit, says James Northam, a senior engineer at Surrey Satellite Technology, a British satellite firm. Stratellites, on the other hand, will cost about $20m each, and can be reused, says Mr Molen: after hovering for 18 months they are recovered for servicing and then relaunched. It all sounds promising on paper—so the real question is whether Sanswire can make the idea fly. ■



It's hardly rocket science

Human-powered health care

Medicine: With its new range of portable and robust wind-up medical devices, Freeplay aims to revolutionise health care in the developing world

TAKE a tour round the wards of a public hospital in sub-Saharan Africa and you will soon see that basic health care can be very basic indeed. Aside from rickety metal beds, heaving with life and death, there is scarcely any equipment to be seen. It is a far cry from the high-tech hospitals in the rich world, where patients are often connected to bleeping, flashing arrays of monitors, pumps and other devices.

Such equipment is rare in poor parts of the world, however, and not just because it is expensive. Electricity supplies in much of the developing world are erratic, if they exist at all, and battery packs to run medical equipment often find their way out of hospitals and into local markets. Moreover, most modern medical devices were not designed with the developing world in mind, so interpreting their complex displays requires trained staff—who are in short supply outside big cities in developing countries. Just as scarce are spare parts: broken equipment usually stays that way.

Freeplay Energy, a British-South African firm, plans to change all that. It is famous for its wind-up radios and mobile-phone chargers which are transforming the way people in poor places with little power communicate. Almost 300,000 Freeplay radios, distributed through development agencies, now bring news and vital information about HIV and other health matters to an estimated 6m people in developing countries. Because Freeplay's products need no batteries—expensive luxuries which tend to be jealously guarded by wage-earning men—women and girls now have access to a world of education and entertainment by radio.

Freeplay has now teamed up with a group of doctors at University College London to create medical equipment that works well in poor parts of the world. The project focuses on neonatal care, and with good reason. Infant death is still a fact of life in much of sub-Saharan Africa and South Asia; roughly 14% of babies born in Angola, for example, die before they reach their first birthday, more than 30 times the rate of infant mortality in Britain. The United Nations Millennium Development Goals set a target of reducing child mortality by two-thirds between 1990 and 2015. While much of that can be achieved through vaccines, clean water and better diet, there is a role for new technology as well. As Rory Stear, Freeplay's boss, points out, 95% of the world's neonatal medical technology is available to only 5% of infants—those born in the rich world.

Keep it simple

Engineers at Freeplay have redesigned four pieces of medical equipment, routinely used in developed countries, to better suit developing ones. The first is a pulse oximeter to measure levels of oxygen in the blood, essential for babies with lung infections because it gives health-care workers early warning that their patients need extra oxygen (and oxygen tanks are one of the few bits of medical equipment available in poor clinics). Second is a syringe driver for delivering small amounts of fluid and drugs in tightly timed doses to babies with diarrhoea and other complaints.

A third device is a microcentrifuge—akin to a tiny, high-speed salad spinner—which takes small samples of blood and spins them at 4,000 revolutions per minute to separate the cells and fluid that make up blood. The colour of one component, called serum, can give doctors an indication of whether their patient is jaundiced, a tricky task in Africa where black babies do not simply turn yellow like white ones. The quantity of red blood cells in the sample can also point to anaemia, a common problem where nutrition is poor. The final lifesaver is a hand-held fetal heart monitor that uses ultrasound to keep tabs on how babies are doing in the womb, which is critical to the health of both mother and child.

All these devices get round the need for mains electricity or batteries by using a handcrank, foot pedal or solar panel to generate energy, which can then power the machines directly or be stored in internal batteries for future use. The machines' software and electronics have also been stripped down to bare essentials, not only to reduce power consumption but also to keep down the cost and size and make them more robust. Pulse oximeters in the rich world, for example, typically have complex LCD read-outs, while fetal heart monitors usually have to be wheeled around on trolleys. Freeplay's hand-held versions lack fancy features, making them smaller, lighter, cheaper and tougher.

Five prototypes of each device are now being tested in hospitals in South Africa. (Initially, they were used in well-equipped hospitals alongside traditional monitoring equipment, to demonstrate their accuracy and reliability.) The results are promising. The fetal heart monitor, for example, has proved as effective as fetal stethoscopes—a conventional way of monitoring fetal health—and patients prefer it because it is more comfortable.

Even so, there is room for improvement, based on feedback from the field. ▸▸

Some of the devices' displays will be changed to provide a continuous, rather than intermittent, read-out. And the microcentrifuge will be retooled to spin at even lower speeds, so that it consumes less energy. Once these improvements have been made, the next step will be to build a few dozen samples of each device and send them out across South Africa for six months of further testing in both urban and rural settings.

One challenge facing the new devices is winning the approval of regulators. The stringent requirements of America's Food and Drug Administration, for example, mean that it can take up to ten years for a medical device to make the journey from drawing board to hospital ward. The FDA's approval is not required in many poor countries, but it is required by some American funding bodies. Freeplay does not plan to seek FDA approval for its new devices just yet, though it has not ruled out doing so in future. While it is important to demonstrate that the new products are safe and reliable, users in the field are more immediately concerned with saving lives than worrying about red tape, says John Hutchinson, Freeplay's director of technology. In most cases, he says, users of the prototype devices did not want to give them back. ■

Your cheating phone

Communications: Do mobile phones make it easier or more difficult to deceive people about your location, activities and intentions?

LIKE many technologies, the mobile phone makes possible new kinds of deception—and new ways to catch out the dishonest. Call someone from a mobile phone, for example, and you can pretend to be anywhere. But if someone calls you, the ringing tone they hear before you answer depends on which country you are in—and may reveal your location. Hong Kong businessmen, for example, once did not dare to leave their mobile phones switched on while visiting sleazy Macau, because the change in ringing tone could betray them. After the ringing tone for Macau was changed to sound like Hong Kong's, however, they could safely leave their phones on, and roaming revenues soared.

As mobile phones become more sophisticated, the possibilities for deception—and for exposing it—are increasing. The latest handsets have high-resolution cameras and satellite positioning, which can prove embarrassing to anyone who lies about their location and is then asked to produce a picture or a satellite fix to prove it. Nemesysco, an Israeli firm, has developed voice-stress analysis software that can, it claims, turn a mobile phone into a rudimentary lie detector. And new "third generation" (3G) mobile phones support video calling, though few people are using it so far.

Jakob Nielsen, a specialist in computer interfaces, worries that all this technology has made its users too accountable. "You don't want your phone to start squealing on you," he says. "Sometimes you might want to take a call by the pool, or in your pyjamas." He need not worry: there is a constant stream of new ways to facilitate phone-based deception.

For example, Liviu Tofan and Razvan Dragomirescu, the founders of Simeda, a German mobile-services firm, wondered whether "blue screen" technology from the television and movie industries, which is used to add fake backgrounds behind presenters and actors, could be applied to mobile video-telephony. Users could then appear to be at the office while lounging on the beach.

When this proved to be too technically difficult, the pair came up with an audio version of their idea instead, called SounderCover. It allows users of certain Nokia handsets to play pre-recorded bursts of traffic noise, airport announcements or other sounds in the background during a conversation. Specific sounds can be assigned to different people in the phone's address book, and triggered when they call. But despite its slogan—"Hide behind sound, make it your alibi"—Mr Tofan says most customers use SounderCover for fun. Many create their own sounds, such as a shoot-out or a love scene, to play tricks on their friends.

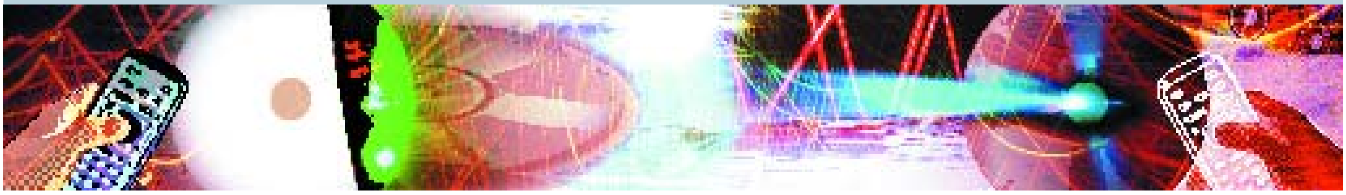
Mobile-phone deception is not limited to tricking people at the other end of the line. Two services offered by American operators, Cingular's Escape-A-Date and Virgin Mobile's Rescue Ring, allow customers to prearrange a call at a given time, to enable them to get out of a disastrous dinner date or boring meeting. With Cingular's service, for example, the phone rings and a recorded voice says: "Hey, this is your Escape-A-Date call. If you're looking for an excuse, I got it. Just repeat after me, and you'll be on your way. 'Not again! Why does that always happen to you? All right, I'll be right there.' Now tell 'em that your room-mate got locked out, and you have to go let them in. Good luck!" (Never believe anyone who tries that excuse, then.)

Both fake background noises and fake emergency calls still require you to be a convincing liar, however. Some people find it difficult to lie in person. One survey, carried out by Freever, a mobile-services firm, found that 45% of Britons had lied about their whereabouts by text message, and 22% would rather text than phone when faking an illness. If you are bad at telling lies yourself, why not outsource the job to someone else?

That is the idea behind "alibi clubs", in which a group of people agree to provide fake alibis for each other. For example, the "Alibi and Excuse Club" was set up last year at SMS.ac, a mobile-chat community. It has since attracted over 6,800 members, though this correspondent's request for someone to provide an excuse to help extend his copy deadline did not produce a response. But a spokesman for SMS.ac recounts several colourful stories told about the club: one member needed an excuse when a baseball game made him late for a party, for example, while another wanted to take a day off from work to go to the beach.

James Katz, a professor of communications at Rutgers University, says alibi clubs are a cute idea and may have some oddball uses, but will only ever appeal to a tiny minority. And even if the tall stories told about such clubs are to be believed—some of them, like the tale of a woman who supposedly broke off her engagement via an alibi club, sound suspiciously like urban legends—the problem remains that the lies told are only ever as convincing as the people who tell them.

Given the limitations of these various mobile-phone deception schemes, perhaps what is needed is a more professional approach: a fee-based service that uses trained actors to deliver plausible, pre-scripted and even personalised alibis. That would surely be more convincing than clunky technological tricks or networks of dubious strangers. No doubt an entrepreneur somewhere is already drawing up a business plan for a new firm: Alibis, Inc. ■



Battle of the blue lasers

Consumer electronics: How previous standards wars compare with today's contest between HD-DVD and Blu-ray

ANOTHER year, another standards war in the consumer-electronics business. From the people who brought you the contest between VHS and Betamax in the 1970s comes a new saga in which two rival—and, inevitably, incompatible—formats struggle to establish themselves as the higher-capacity successor to the wildly popular DVD standard. Both new formats rely on blue lasers, which can discern finer details than the red lasers used in DVD players, to squeeze more data on to each disc. This capacity can be used in two ways: to boost quality, by providing a more detailed "high definition" picture, or to increase quantity, enabling more footage (at DVD quality) to fit on a single disc.

In one corner is the HD-DVD format, backed by Toshiba, NEC and Sanyo. The details are still sketchy—the specification will not be finalised until February—but HD-DVD will offer at least three times the storage capacity of DVD, while improved video-compression software will further boost capacity. The new format has the backing of the DVD Forum, which means it is the "official" successor to the DVD format. Proponents of HD-DVD claim the discs can be made cheaply using existing DVD production lines with very little modification. The first HD-DVD devices will go on sale next year.

In the other corner is Blu-ray, backed by a consortium that includes Sony, Matsushita, Hitachi and Philips. Blu-ray discs have around five times the capacity of DVDs, allowing each disc to store around two hours of high-definition video, or 13 hours of standard video. Sony has been selling Blu-ray recorders in Japan since 2003, and Matsushita and Sharp have both launched Blu-ray devices this year.

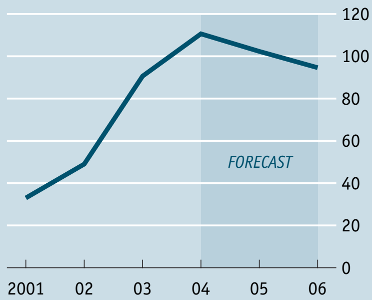
The battle between the two standards has heated up in recent months as the two camps fight to sign up hardware vendors and content producers, notably Hollywood studios, which have determined the outcome of previous standards wars.

So how will the battle play out? Previous standards wars have been resolved in one of four different ways.

The first possibility is a compromise between the two rival formats, as happened in 1995 with the DVD standard. Originally, Sony and Philips proposed a technology called MMCD, while Toshiba and its allies pushed a rival standard called SD. After much wrangling, a standards war was averted when Hollywood demanded a single format. Sony compromised, and the result was the DVD, which is very similar to SD but borrowed some elements from MMCD. This time, however, such a compromise seems unlikely, says Shyam Nagrani, an analyst at iSuppli, a market-research firm. "Nobody wants to bend," he says, since neither side wants to give up the lucrative royalties it stands to make if its standard prevails. Instead, both sides are digging in for a long fight.

Follow that

Worldwide sales of DVD players, m



Source: iSuppli

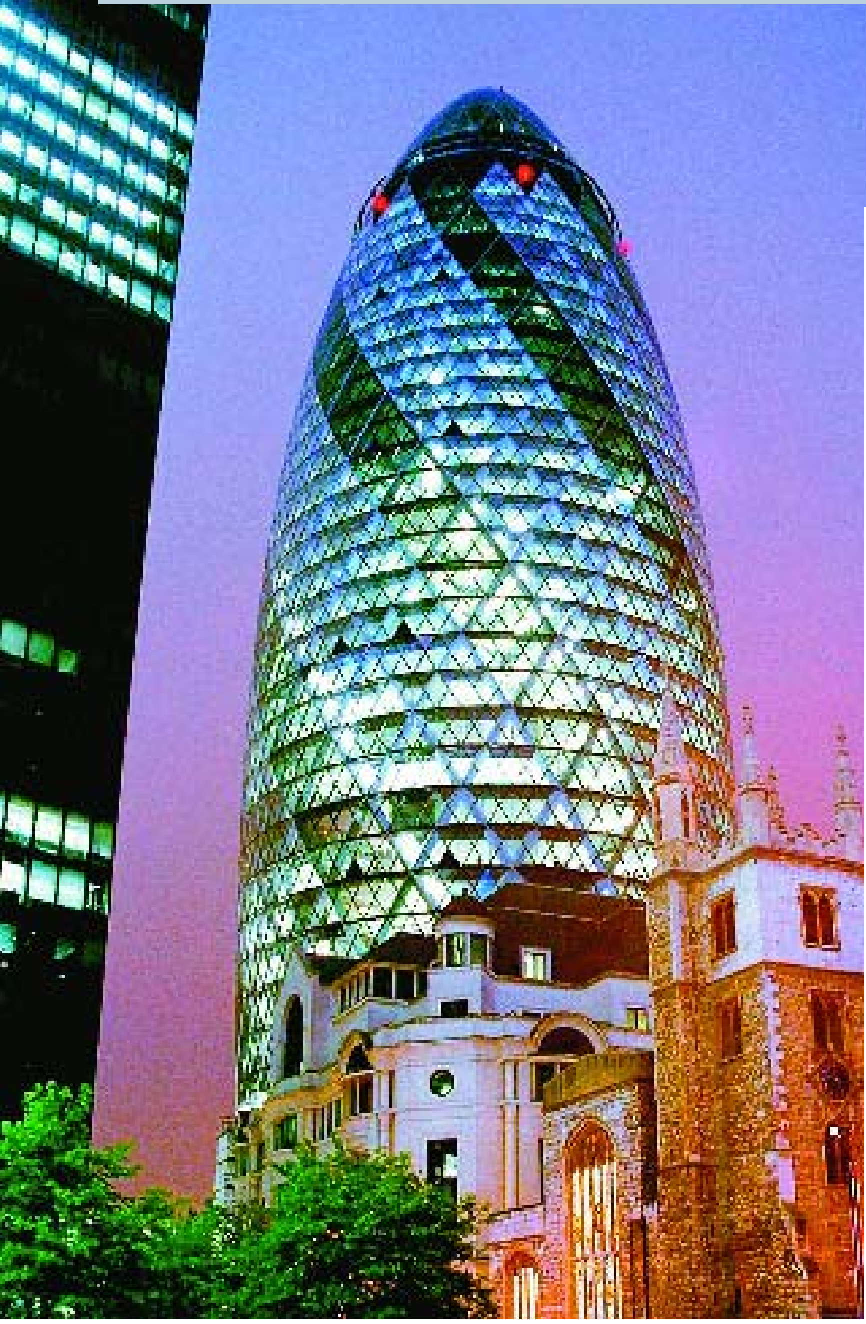
A second possible outcome is that the two standards will coexist, and dual-format players capable of handling both kinds of disc will render the standards war irrelevant—as happened in the tussle over recordable DVDs. The DVD Forum backed a recordable format called DVD-R, but several firms, including Sony and Philips, chose to back a rival format called DVD+R. Players capable of reading and writing both kinds of disc have, however, now largely rendered the disagreement moot. Vamsi Sistla, an analyst at ABI Research, believes the same could happen with HD-DVD and Blu-ray. Building a player that works with both kinds of disc will be difficult, he concedes, but consumer-electronics firms support multiple competing formats in other areas. Yet Mr Nagrani argues that in this case the two formats are so different that dual-format players would be far too expensive.

A third possibility is that the market will be stillborn: the lack of a common standard will deter consumers from upgrading, as happened with the two rival successors to the CD audio format, DVD-A (backed by the DVD Forum) and SACD (backed, inevitably, by Sony and Philips). Hybrid players can now play both kinds of disc, but neither format has taken off. Music and video are, however, very different. The popularity of the MP3 format suggests that most people are not too bothered about audio quality. In the case of video, however, there is a reason to upgrade. The new high-capacity discs will be able to hold an entire series of a sitcom, and there is bound to be demand for high-definition versions of popular movies such as "Lord of the Rings" and "Star Wars" that feature spectacular special effects. And as large televisions become more popular, says Mr Nagrani, people will demand higher image quality.

There can be only one

All of this suggests that the most likely outcome is a fight to the death, as happened with VHS and Betamax. Historically, Sony has often been in the losing camp, starting with Betamax. This time around, however, Sony has several factors in its favour. For one thing, Blu-ray is the more mature technology, and is already shipping. Second, Sony now owns two of the top ten Hollywood studios; its recent acquisition of MGM was widely assumed to be motivated in large part by a desire to bolster support for Blu-ray.

But the potential ace up Sony's sleeve is its next-generation games console, the PlayStation 3, which will use Blu-ray discs to store games and will double as a Blu-ray player. If Sony can launch the console next year, before HD-DVD devices become widely available, it may be able to establish critical mass for Blu-ray. Yet if the Hollywood studios come down firmly in favour of HD-DVD, that could relegate Blu-ray to obscurity. The next few months will be critical, and the battle could still go either way. "By late 2005 it will be very clear who the winner is going to be," says Mr Nagrani. Technology may have moved on since the time of the VHS and Betamax contest—but unfortunately for consumers, standards wars persist. ■



The rise of the green building

Architecture: New buildings use design and technology to reduce environmental impact, cut costs and provide better places to work

IT IS officially known as the Swiss Re Tower, or 30 St Mary Axe. But Londoners universally refer to the newest addition to their skyline as "the Gherkin", thanks to the 41-storey building's distinctive, curved profile, which actually looks more like a pine cone (see above). What is most remarkable about the building is not its name or its shape, however, but its energy-efficiency. Thanks to its artful design and some fancy technology, it is expected to consume up to 50% less energy than a comparable conventional office building.

Most people are not used to thinking of large buildings as vast, energy-guzzling machines. But that is what they are. In America, buildings account for 65% of electricity consumption, 36% of total energy use and 30% of greenhouse-gas emissions. So making buildings more energy-efficient could have a significant impact on energy policy, notes Rebecca Flora of the Green Building Alliance, a group that promotes sustainable architecture. That is a key goal of the "green architecture" movement, which is changing the way buildings are designed, built and run.

Proponents of green architecture argue that the approach has many benefits. In the case of a large office, for example, the combination of green design techniques and clever technology can not only reduce energy consumption and environmental impact, but also reduce running costs, create a more pleasant working environment, improve employees' health and productivity, reduce legal liability, and boost property values and rental returns.

The term "green architecture" only came into use in the 1990s, but the movement's roots can be traced back a long way. Crystal Palace in London and Milan's Galleria Vittorio Emanuele II, for example, built in 1851 and 1877 respectively, used roof ventilators and underground air-cooling chambers to regulate the indoor temperature. Today's enthusiasm for green architecture has its origins in the energy crisis of the 1970s, when architects began to question the wisdom of building enclosed glass-and-steel boxes that required massive heating and cooling systems. Early proponents of more energy-efficient architecture included William McDonough, Bruce Fowle and Robert Fox in America, Thomas Herzog in Germany, and Norman Foster and Richard Rogers in Britain.

These forward-thinking architects began to explore designs that focused on the long-term environmental impact of maintaining and operating a building, looking beyond the so-called "first costs" of getting it built in the first place. This approach has since been formalised in a number of assessment and rating systems, such as the BREEAM standard introduced in Britain in 1990, and the LEED (Leadership in Energy and Environmental Design) standards developed by the United States Green Building Council (USGBC) starting in 2000.

The LEED standards are intended to produce "the world's greenest and best buildings" by giving developers a straightforward checklist of criteria by which the greenness of a building can be judged. Points are awarded in various categories, from energy use (up to 17 points) to water-efficiency (up to five points) to indoor environment quality (up to 15 points); the total then determines the building's LEED rating. Extra points can be earned by installing particular features, such as renewable-energy generators or carbon-dioxide monitoring systems. A building that achieves a score of 39 points earns a "gold" rating; 52 points earns a "platinum" rating. A gold-rated building ▸▸

Clockwise from bottom left: Pittsburgh's convention centre, Toyota's building at Torrance, and New York's future Freedom Tower

is estimated to have reduced its environmental impact by 50% compared with an equivalent conventional building, and a platinum-rated building by over 70%.

Rating buildings in this way reveals how inefficient traditional buildings and building processes are. "We can sometimes waste up to 30 cents on the dollar," says Phillip Bernstein, an architect and professor at Yale University. "It's not just the consumption of energy, it's the use of materials, the waste of water, the incredibly inefficient strategies we use for choosing the subsystems of our buildings. It's a scary thing." In part, he says, this is because the construction industry is so fragmented. Designers, architects, engineers, developers and builders each make decisions that serve their own interests, but create huge inefficiencies overall.

Green is good

But things are now changing, as green architecture moves into the mainstream. In the spring of 2003, Toyota completed a 624,000-square-foot office complex in Torrance, California, that received a LEED gold rating, thanks to the inclusion of features such as solar cells to provide up to 20% of the building's energy needs. Also last year, Pittsburgh opened the doors on its 1.5m-square-foot convention centre, the largest building to be awarded a gold LEED rating so far. The USGBC says nearly 1,700 buildings in 50 states are now seeking LEED certification and 137 have been constructed and certified so far. And America's General Services Administration, which oversees all non-military government construction, recently decreed that all new projects and renovations must meet the minimum LEED standards.

In Britain, meanwhile, 70 office buildings constructed during 2003, representing 25% of the total by floor area, met the BREEAM standard. Similar standards have been adopted in New Zealand, Australia and Canada. In China, the Beijing Organising Committee of the Olympic Games aims to host the first zero-net-emissions games, which will include constructing all buildings and sports venues using green-architecture principles.

There are many ways to reduce a building's environmental impact. Consider the 48-storey Condé Nast Building at 4 Times Square in New York, for example, which was designed by Fox & Fowle Architects. It was one of the first examples in which green-architecture principles were applied to a large urban office building, and informed the drawing up of the LEED points system, since it uses almost every energy-saving technique imaginable.

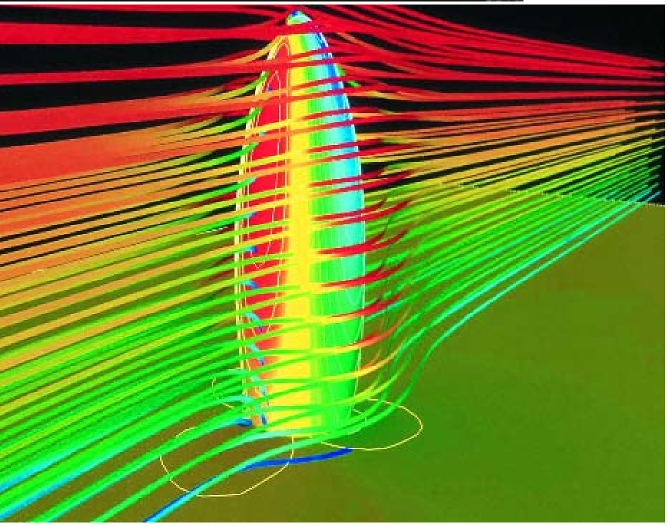
Special glass allows daylight in to reduce the need for interior lighting, keeps heat and ultraviolet rays out, and minimises heat loss in winter. Two natural-gas-powered fuel cells provide 400 kilowatts of power, enough to provide all the electricity needed at night, and 5% of the building's needs during the day. The hot-water exhaust produced by the fuel cells is used to help heat the building and provide hot water. The heating and cooling systems, located on the roof, are gas-powered rather than electric, which reduces energy losses associated with electrical power transmission. Photovoltaic panels on the building's exterior provide up to an additional 15 kilowatts of power. Inside the building, motion sensors control fans and switch off lights in seldom-occupied areas such as stairwells. Exit signs are illuminated by low-power light-emitting diodes. The result is that the building's energy consumption is 35-40% lower than that of a comparable conventional building.

30 St Mary Axe, designed by Foster and Partners, is also packed with energy-saving features. In particular, it uses natural lighting and ventilation wherever possible. The façade consists of two layers of glass (the outer one double-glazed) enclosing a ventilated cavity with computer-controlled blinds. A system of weather sensors on the outside of the building monitors the temperature, wind speed and level of sunlight, closing blinds and opening window panels as necessary. The building's shape maximises the use of natural daylight, reducing the need for artificial lighting and providing impressive long-distance views even from deep inside the building.

The highest-profile green building currently on the drawing board is the Freedom Tower, which will be built on the site of the World Trade Centre in New York. The architects, Skidmore, Owings & Merrill and Studio Daniel Libeskind, have incorporated environmental design features throughout the huge complex. The main tower, which will rise 1,776 feet, will include solar panels and a wind farm, the turbines of which are expected to deliver around one megawatt of power, enough to provide up to 20% of the building's expected demand. Like other green buildings, it will rely on natural light and ventilation, and energy-efficient lighting.

High energy costs, environmental concerns and anxiety about the "sick building syndrome" associated with the sealed-box structures of the 1970s all helped to jump-start the green-architecture movement. But now economics is

“Going green saves money by reducing energy and maintenance costs, and may boost productivity.”



driving the shift towards greener design, as new materials and techniques fall in price, argues Michael Crosbie, an architect at Steven Winter Associates, a consultancy based in Norwalk, Connecticut. He says his clients “are much more demanding because they see the incredible amount of money it takes to get something constructed, and they want a return on that investment.”

Why it pays to be green

Going green saves money by reducing long-term energy costs: a survey of 99 green buildings in America found that on average, they use 30% less energy than comparable conventional buildings. So any additional building costs can be recovered quickly: according to the USGBC, the 2% increase in construction costs required to achieve a LEED gold rating typically pays for itself in lower running costs within two years. The traditional approach of trying to minimise construction costs, by contrast, can lead to higher energy bills and wasted materials.

Energy-saving techniques need not all be as exotic as installing coated glass, computer-controlled blinds or photovoltaic cells. Mr Crosbie says builders are now insulating buildings more effectively, in some cases using materials such as recycled paper and fabrics, including old, shredded jeans. It is more effective than traditional insulation, he says, saves money and is easier on the environment.

Green buildings can also have less obvious economic benefits. The use of natural daylight in office buildings, for example, as well as reducing energy costs, also seems to make workers more productive. Studies conducted by Rachel and Stephen Kaplan, environmental psychologists at the University of Michigan, found that employees with views of a natural landscape report greater job satisfaction, less stress and fewer illnesses. Lockheed Martin, an aerospace firm, found that absenteeism fell by 15% after it moved 2,500 employees into a new green building in Sunnyvale, California. The increase in productivity paid for the building’s higher construction costs within a year.

Similarly, the use of daylight in shopping complexes appears to increase sales. The Heschong Mahone Group, a California-based consultancy that specialises in energy-efficient building technologies, found that sales were as much as 40% higher in stores lit with skylights. It also found that students in naturally lit classrooms performed up to 20% better. Green buildings can also reduce legal liabilities for their owners, since they are less likely to give rise to “sick building” lawsuits. But more studies are needed, says Caren Glotfelty, director of the environmental programme at the Heinz Endowments, a nonprofit foundation run by Teresa Heinz Kerry that funds sustainable initiatives.

Despite its benefits and its growing popularity, green architecture is still the exception, not the rule, however. The main problem is co-ordination, says Mr Bernstein, who is also vice-president of the building solutions division at Autodesk, a software company. Green buildings require much more planning by architects, engineers, builders and developers than traditional buildings. “The building industry is very disaggregated,” he says, “so adoption patterns are really, really slow.” But new software is now improving planning by simulating how a building will perform before it is built.

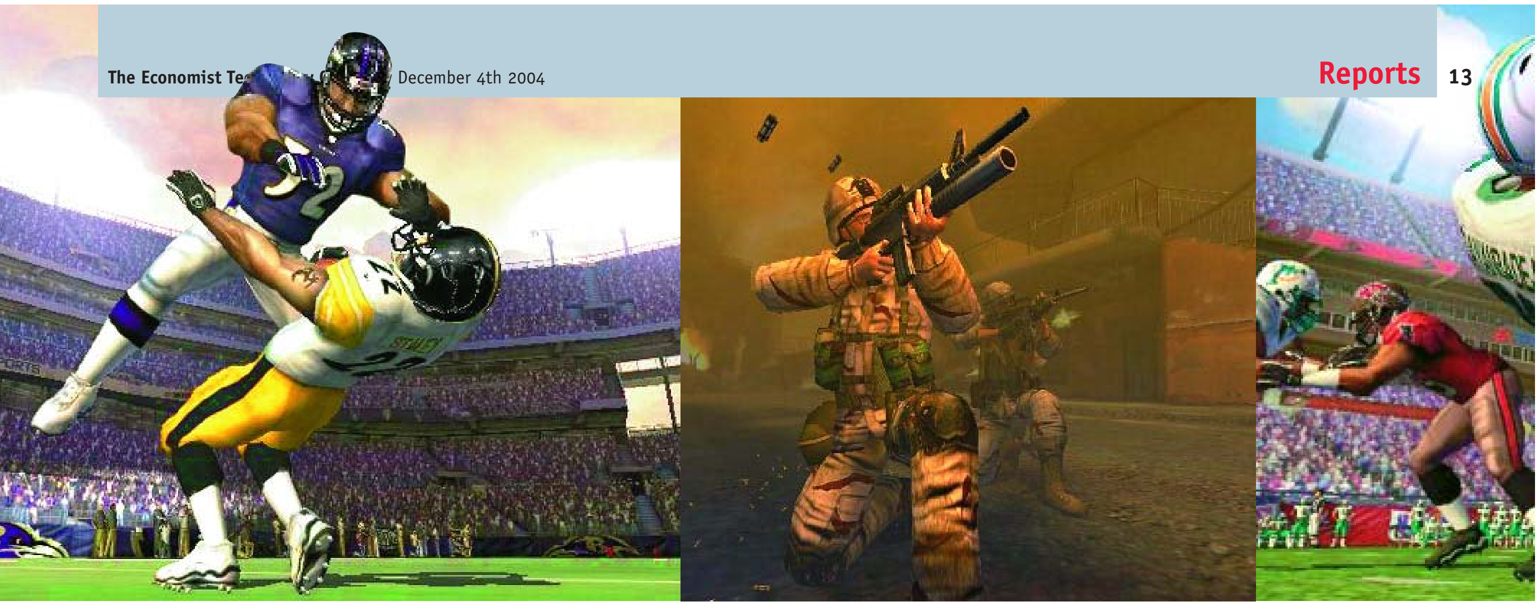
Autodesk’s software can create a three-dimensional model of a building and then work out how much energy it will use, taking into account its shape, heating and cooling systems, orientation to the sun and geographic location. Other such tools abound: the designers of 4 Times Square calculated its energy consumption using a free package called DOE-2, developed by James J. Hirsch & Associates together with the Lawrence Berkeley National Laboratory, with funding from America’s Department of Energy.

Greener by design

In the old days, says Mr Bernstein, assessing a building’s environmental impact had to be done with spreadsheets, calculators and informed guessing, and three-dimensional modelling was primarily used to prepare presentations. But now the three-dimensional computer models are being used with sophisticated analytical tools. “We are getting to the next phase where you can analyse rather than simply represent,” he says. It is then possible to predict how much energy and water a building will consume, how much material will be needed, and other parameters that determine its LEED certification. All of this is old hat for the airline and automobile industries, where computer models have long been used to trim costs and streamline design before construction begins. Now the same technology is being applied by architects.

Computers also make possible entirely new designs. 30 St Mary Axe, for example, could not have been built without a computer model to specify the exact shape of every one of its 5,500 glass panels, or to model the airflow in and around it. Similarly, computer modelling made possible the Avax office building completed in Athens, Greece, in 1998. It has sheaves of glass which open and close automatically, depending on the intensity and angle of the sun, to provide sunlight while preventing the building from overheating. The ventilation system in Pittsburgh’s convention centre uses the natural “chimney effect” created by its sweeping roof to draw air through vents by the river below, cooling the building without using a single fan.

This is more than a mere fad, or the use of technology for the sake of it, says Mr Bernstein. Green architecture will, he suggests, help to reshape the construction industry over the next five years, with ever more innovative, energy-efficient and environmentally friendly buildings. “No one is doing this for fun,” he says. “There’s too much at stake.” ■



Playing to win

Computing: How close is the relationship between real-world skills and video games, on playing fields and battlefields?

IS DWIGHT FREENEY the best player in America's National Football League (NFL)? He has a clearer grasp than anyone else of the strategy and tactics necessary to win in the brutal, chaotic game. He also has the quick reactions necessary to respond to the rapidly changing conditions at the line of scrimmage, where nimble 150kg giants, bulging with padding and sporting helmets and face-masks, barrel into and around each other. How can you tell? He won the 2004 "Madden Bowl", a video-game tournament in which NFL players compete on screen, rather than on the field, and which is held each year just before the Super Bowl, the championship of real-world American football. On the screen, Mr Freeney dominated, holding his opponents scoreless.

On the real-world field too, Mr Freeney is by all accounts a good player. A defensive end, he is unusually fast and can put a great deal of pressure on the opposing team's quarterback. However, in the 2003-04 season, when Mr Freeney won the Madden Bowl, the defensive line for his team, the Indianapolis Colts, was one of the worst in the league, according to footballoutsiders.com, a website which performs rigorous statistical analyses of the game of football. So far this year, the Colts' defensive line is ranked dead last. Other football players who did well in the virtual championship—such as David Carr, a mid-ranked quarterback for the Houston Texans, and Dante Hall, a mediocre wide receiver for the Kansas City Chiefs—have similarly unremarkable records in real life.

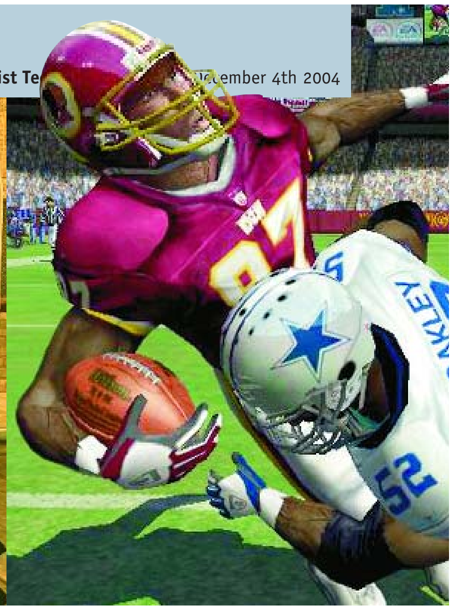
Mr Freeney demonstrates that real-world skills translate readily into the virtual world: professional football players turn out to be good at virtual football, too. But what if the skills do not translate in the other direction? The assumption that skills learned in a simulated environment can be readily transferred into the real world is widespread in fields including pilot training and, increasingly, military training. But is it correct?

Lock and load

As video-game technology has steadily improved and the gadgets of war have grown more expensive, America's military is relying more heavily on computer games as training tools. Some games which the military uses are off-the-shelf products, while others are expensive, proprietary simulations. A 2001 report by RAND, a think-tank, boosted the enthusiasm for military gaming when it concluded that the middle ranks of the army were experiencing a "tactical gap". Because most lieutenants and captains had not commanded troops in battle, or had not trained extensively enough in mock battles, they lacked the know-how necessary to do their jobs well. Fixing this, either by keeping infantry commanders in their jobs longer or by stepping up the pace of training, proved difficult—which led to a proliferation of initiatives in different branches of the military to develop games for training purposes.

The "tactical gap" may now have disappeared, as a result of the war in Iraq. A paper published this summer by Leonard Wong of the Army War College in Carlisle, Pennsylvania, asserts that the "complexity, unpredictability and ambiguity of post-war Iraq is producing a cohort of innovative, confident and adaptable junior officers". Nonetheless, games remain a far cheaper training method than invading countries and waging wars. Yet their true effectiveness is far from certain. An eagerness on the part of the military to save money and embrace a transformative mission, and an eagerness on the part of the gaming community to see itself as genuinely useful, rather than as merely providing frivolous entertainment, may be obscuring the real answers.

In the case of football, there is no shortage of data to analyse. Not only is there a score at the end, and a clear winner and loser, but a multitude of data can be harvested as the game is under way—passes completed, sacks allowed, fumbles forced and so on. For those unfamiliar with American football, the details of these data are unimportant—the relevant fact is that they exist. The same cannot be said on a battlefield. In the proverbial fog of war, there is no easy way quantitatively to ▸▸



measure success or failure in the many different aspects of warfare.

Other sports, especially baseball, offer a greater wealth of data. However, no other sport seems to match the set of psychological and physical skills needed on a battlefield so well. Vince Lombardi, probably the most famous coach in American football's history, enjoyed comparing the football field to a battlefield. But the more important comparison is the converse—that a battlefield can seem like a football field, according to Lieutenant-Colonel James Riley, chief of tactics at the Army Infantry School in Fort Benning, Georgia. Indeed, Colonel Riley says his commanding general makes this very analogy constantly. In football, as in infantry combat, a player must be aware of both the wider situation on the field, and the area immediately surrounding him. The situation changes rapidly and the enemy is always adapting his tactics. Physical injuries abound in both places. Football is as close to fighting a war as one can come without guns and explosives.

The generals would thus be chagrined to hear Mr Freeney say that while playing football has made him better at the video game, the video game has not affected his real-world performance. Mr Freeney highlights the surreal experience of playing a video game where he knows the on-screen characters (EA Sports, the manufacturer of Madden, is proud of its realistic depictions of real-world football players) and indeed of playing as himself on screen. "It's not the total Dwight Freeney," he says. "There are some similarities." For the military, which is training soldiers for life or death situations, are "some similarities" enough?

According to Colonel Riley, they just might be. All training exercises, whether in a mocked-up urban combat environment or on a computer screen are, he says, "partial task simulators". The army will not, after all, actually try to get its soldiers to kill each other for practice. And Colonel Riley asserts that some games, in particular "Full Spectrum Command", a game he uses to train infantry captains, can usefully impart a partial skill set. The single most important thing for a simulation to achieve, he says, is the suspension of disbelief. This is easy to achieve in, say, a flight simulator. When flying a real aircraft, the pilot sits in a seat and manipulates controls, looking at a screen—much as he does in a simulator.

"The goal of OneSaf is to simulate the entire army. If it works, it will allow commanders to evaluate the effects of new tactics or hardware."

But simulating infantry combat, as Colonel Riley is doing, is much more difficult. As he admits, he is not certain how much "simulation dexterity translates into reality". However, he maintains that "Command" is a useful training tool. An infantry captain commands a company of 130 men. Without the simulation, putting a new captain through an exercise meant using 129 men as training tools—an enormous overhead. Colonel Riley says that the simulation, however flawed, is an improvement. It can help to teach a captain battlefield tactics—how to deploy troops, when to call in artillery or airstrikes, and so on. And Colonel Riley says that the game has sufficient fidelity to the real world: the graphics are good enough, and the artificial intelligence of the enemy clever enough, to help teach captains how to make command decisions.

Paradoxically, the larger the scale of the situation being simulated, the better and more useful a simulation might be. "Full Spectrum Warrior", a game which, like "Command", was developed under the auspices of the Institute for Creative Technologies (ICT), a military-funded centre at the University of Southern California, is a "first-person shooter" game which simulates infantry combat at the squad level—ten individuals or so. It has received a lot of attention because it exists in two versions—one of which is used as a military training tool, while the other is on sale to the public.

The ICT trumpets it as an especially accurate rendition of close infantry combat, developed in co-operation with the infantry school at Fort Benning. However, Colonel Riley says that it does not meet the needs of any of his courses, and that when infantrymen play the game, they complain of its lack of fidelity. The smaller the simulation, the bigger the disjunction between the tasks necessary in reality and those on the computer.

The opposite extreme is exemplified by OneSaf, a large-scale simulation being developed by the army in Orlando, Florida. The goal of OneSaf is extremely ambitious: to simulate the entire army. Unlike "Warrior" and "Command", it is not meant to be used as a training tool to hone soldiers' instincts, but by planners and, in the long run, even front-line troops, to see what would happen in a given situation. OneSaf is an enormously complicated software framework which is expected to take years to develop.

It will surely not be a perfect recreation of the world. But it illustrates the power of technology to be transformative in a way that "Warrior" and "Command" are not—since they are not as good as training exercises in the field, but merely a cheaper alternative. OneSaf, if it works, will allow commanders to see in a virtual world the effects of new tactics or hardware—a fundamentally new capability. Rather than merely recreating the world, in short, elaborate simulations might someday be powerful enough to change it. ■

Why the future is hybrid

Automotive technology: Hybrid petrol-electric cars such as the Toyota Prius are becoming increasingly popular. But are they any more than a rest-stop on the road to the hydrogen car?

WHY has the Toyota Prius become the car industry's most talked about product? Since 1997, only about 250,000 have been sold, a paltry number by the industry's standards. The Prius is hardly big, fast or beautiful—the attributes that usually appeal to commentators, aficionados or, for that matter, buyers. And yet it is significant because it is the world's first mass-produced petrol-electric hybrid car, powered by both an internal-combustion engine and an electric motor. The second-generation Prius, launched in 2003, won some of the industry's most prestigious awards—it has just been named European Car of the Year 2005—and generated a buzz out of all proportion to the car's prevalence on the roads.

By choosing to drive a Prius, buyers can demonstrate how green they are without paying any penalty other than a slightly higher purchase price. Compared with a new American car of the same size, the Prius consumes roughly half as much petrol, and so releases half as much climate-changing carbon dioxide. Moreover, its emissions of smog-forming pollutants, such as nitrogen oxides and hydrocarbons, are 90% lower. Yet the Prius still manages to deliver the comfort and performance of a conventional car.

The success of the Prius has taken Toyota by surprise. The average wait at American dealerships is currently six months, even though the company increased its sales target for North America from its initial estimate of 36,000 units to 47,000 for 2004. To meet demand, Toyota announced another increase in August, saying it would push monthly global production up next year by 50% to 15,000 cars, and double its allotment for America to 100,000 units. While that number is still only one-quarter of last year's sales for America's most popular Toyota model, the Camry, it shows that consumers are willing to pay a premium for clean, environmentally friendly cars—as long as there is no need to compromise on performance.

Other carmakers are scurrying to catch up. CSM Worldwide, an automotive research firm, reckons that at least 20 new hybrid models will appear in America by 2007. Besides this year's new Ford Escape and Honda Accord hybrids, Toyota will add two sport-utility vehicles (SUVs) to its hybrid line-up early next year. DaimlerChrysler recently announced that it will introduce a Mercedes hybrid within the next five years, and Porsche is considering a hybrid version of its Cayenne SUV. Even General Motors, one of the strongest proponents of hydrogen fuel-cell cars, has jumped on the hybrid bandwagon with two pick-up trucks, a sedan and several SUVs to follow. Thanks to the convergence of geopolitics, technology and fashion, hybrids are picking up speed.

An old new idea

While the arrival of mass-produced hybrids is new, the idea itself is not. Indeed, it dates back to early automotive history when cars powered by electric motors, steam or internal-combustion engines all accounted for significant shares of the market. Why hybrids failed then is best illustrated by the example of an American engineer named H. Piper, who filed a patent for a petrol-electric hybrid vehicle in 1905. His idea was to use an electric motor to assist an internal-combustion engine, enabling it to achieve a thrilling 40kph (25mph). Unfortunately for Mr Piper, petrol-powered internal-combustion engines achieved those speeds on their own just a few years later, undermining the more complex and expensive hybrid approach. Petrol engines soon ruled the roost.

Priorities began to change in the early 1970s, when the oil crisis increased demand for less fuel-thirsty cars. As a result, the overall fuel efficiency of cars and trucks improved dramatically (though it stalled in America in the late 1980s as cheap petrol and a regulatory loophole encouraged sales of SUVs and light trucks). Moreover, in the 1990s, concern began to grow over the impact of fossil-fuel consumption on climate change.

During the 1990s, all of the big three American carmakers developed diesel-electric hybrid concept cars, though none made it into production. Instead, the focus shifted to pure-electric vehicles, which are technologically simpler than hybrids. But their high cost and limited range deterred consumers. Even the most advanced models could only go about 100 miles before they needed to be plugged in and recharged for several hours. By 2000, most electric cars had been taken out of production.

Meanwhile, Toyota released its first Earth Charter in 1992, setting the goal of minimising its overall environmental impact. In September 1993, the company began to plan the development of a car for the next century, dubbed Globe 21st Century, or G21. Originally, the plan was to produce a car with 50% better fuel economy than existing vehicles. But over the course of the project this target was raised to 100%, at which point it became clear that tweaking a petrol engine would not suffice. Instead, a more radical solution would be needed: a hybrid.

Despite the higher cost and complexity of a hybrid system, Toyota decided to press ahead with a massive research and development effort. Improved technology—such as better batteries and cheaper, more powerful control electronics to co-ordinate the two propulsion systems—meant that a mass-produced hybrid was now feasible. In 1997, the Prius was launched in Japan. It was followed by Honda's Insight hybrid in 1999.

When the Prius went on sale in America in 2000, it did not cause much of a stir. Indeed, even last year, Honda and Toyota sold about the same number of hybrids in America. This year, however, Toyota will sell about twice as many as Honda. The Prius took off thanks to the combination of rising petrol prices, celebrity endorsements and a futuristic redesign. (There is no petrol version of the Prius, so the car makes a statement in a way that the Honda Civic, which is available in both petrol and hybrid versions, does not.) It is the first hybrid to become a hit.

Hybrid anatomy

There is more to the Prius than clever marketing, however. To understand why, it is necessary to look under the bonnet at the way different kinds of hybrids work—for not all hybrids are the same. The simplest kind is the "stop-start" or "micro" hybrid, which is not generally regarded as a true hybrid because it relies solely on an internal-combustion engine for propulsion. As the "stop-start" name implies, the engine shuts off when the vehicle

"Consumers will buy environmentally friendly cars provided there is no compromise on performance."

comes to a halt. An integrated starter-generator restarts the engine instantly when the driver steps on the accelerator. All of this increases fuel efficiency only slightly, typically by around 10%. But few modifications to a conventional design are required, so it costs very little. In Europe, PSA Peugeot Citroën has just introduced a stop-start version of the Citroën C3, which sells for roughly the same price as a similarly equipped conventional C3.

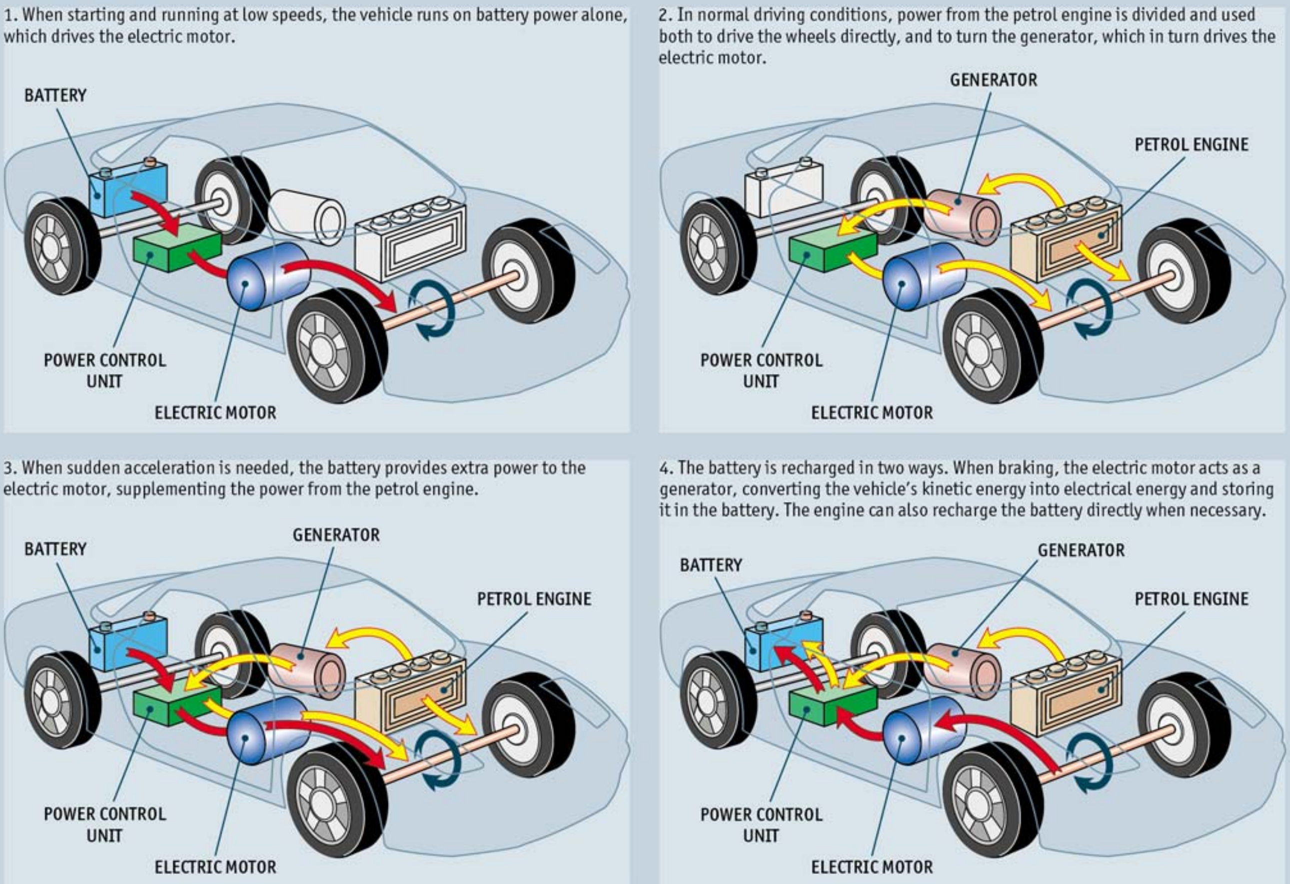
Next come so-called "mild" hybrid designs, such as Honda's Integrated Motor Assist (IMA)—the hybrid configuration found in the Insight, the Civic and the new Accord. In addition to a stop-start function, an electric motor gives the engine a boost during acceleration. During braking, the same motor doubles up as a generator, capturing energy that would otherwise be lost as heat and using it to recharge the car's batteries. Since the electric motor is coupled to the engine, it never drives the wheels by itself. That is why this system is called a mild hybrid, much to Honda's dismay. The design is less expensive than Toyota's more elaborate approach, but can provide many of the same benefits, says Dan Benjamin of ABI Research, a consultancy based in Oyster Bay, New York. The hybrid version of the Civic achieves 48 miles per gallon, a 37% improvement over a comparable conventional Civic.

Toyota's Hybrid Synergy Drive, a "full" hybrid system, is much more complex. (The Ford Escape hybrid uses a similar system; Ford licenses a number of patents from Toyota.) Using a "power split" device, the output from the petrol engine is divided and used both to drive the wheels directly and to turn the generator, which in turn drives the electric motor and also drives the wheels. The distribution of power is continuously variable, explains David Hermance of Toyota, allowing the engine to run efficiently at all times. When its full power is not needed to drive the wheels, it can spin the generator to recharge the batteries. The batteries also get replenished when the car is coasting or braking. During stop-and-go traffic and at low speeds, when the petrol engine would be most inefficient, it shuts off and the electric motor, powered by the battery, takes over. That explains why the Prius has a better fuel economy rating for urban driving (60 miles per gallon) than for motorway driving (51 miles per gallon)—the opposite of a conventional vehicle.

The next step may be the "plug-in" hybrid, which is not the backwards step its name suggests. Unlike the electric cars of the 1990s, none of today's hybrids needs to be plugged in—but if plugging were an option it would be a good idea. Andrew Frank and his team at the University of California Davis' Hybrid Electric Vehicle

Hybrid vigour

How the Prius works



Source: Toyota

"The beauty of hybrids is that they do not require changes in driver behaviour or fuel infrastructure."

Centre are working exclusively on plug-in hybrids, which can operate as pure-electric vehicles over short distances (up to 60 miles, with a large enough battery pack) but can switch to a hybrid system when needed. Since the average American driver travels about 30 miles a day, plug-in hybrids could be recharged overnight, when electricity is cheaper to produce, and need never use petrol at all, except on longer trips.

According to studies carried out by the Electric Power Research Institute (EPRI), a non-profit organisation based in Palo Alto, California, plug-in hybrids could be one of the cleanest and most efficient kinds of car. In 2002, the EPRI teamed up with DaimlerChrysler to build five plug-in hybrid vans, the first of which was unveiled at a trade show in September. The larger battery packs make the up-front costs for plug-ins higher than for other hybrids. But Bob Graham of the EPRI says the added costs could be more than recouped over the vehicle's life.

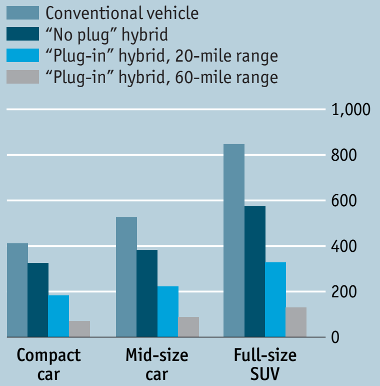
Not everyone is bothered by high fuel consumption, however, as the current enthusiasm for enormous SUVs demonstrates. So hybrids seem likely to remain a niche: ABI Research predicts that by 2010, less than 5% of all cars sold in America will be hybrids, assuming current petrol prices persist. But if Alan Lloyd has his way, hybrids and other low-emission vehicles will become far more commonplace. Dr Lloyd is head of the California Air Resources Board (CARB), a state agency that enforces arguably the most stringent air quality rules in the world. California recently passed landmark legislation to curb the emissions of greenhouse gases by 30% beginning in 2009. Since carbon-dioxide emissions are directly linked to a car's fuel consumption, critics charge that the new rules are in effect a way to legislate fuel economy, which is supposed to be regulated by the federal government, not the states. As a result, carmakers are expected to challenge the new rules in court.

Sales of hybrids in Europe are a fraction of those in America. Instead, diesel cars have become Europe's answer to reduce fuel consumption, curb greenhouse emissions and save money at the pump. Because diesel fuel contains more energy per unit, the fuel economy of diesel cars is roughly 30% better than that of petrol-powered cars. Moreover, diesel cars are not as loud or dirty as they once were, thanks to technologies such as electronically controlled "common rail" fuel-injection systems. Diesels now make up about 45% of all newly registered cars in Europe.

Even so, they still lag behind petrol engines in terms of cleanliness. In the process of combustion, diesels create a lot of pollution, including nitrogen oxides which cause smog, and particulate matter that can cause respiratory problems. That said, some carmakers have begun to equip their cars with particulate filters, notably PSA Peugeot Citroën. Together with two British firms, Ricardo and QinetiQ, the company is building a diesel-hybrid based on the family-sized Citroën Berlingo. The aim is to achieve a combined fuel economy of 70 miles per gallon with carbon-dioxide emissions of only 90 grams per kilometre. (In comparison, the Prius delivers 55 miles per gallon with carbon-dioxide emissions of 104 grams per kilometre.)

Easy on the gas

Average annual petrol consumption by vehicle type, US gallons



Source: EPRI/DaimlerChrysler

While it is uncertain whether the car will be mass produced, it is clear that a diesel-electric hybrid would make for an extremely frugal vehicle. A study by the Laboratory for Energy and the Environment at the Massachusetts Institute of Technology, which looked at energy use over the course of a vehicle's life, predicts that by 2020, diesel hybrids could achieve the same energy-efficiency and greenhouse-gas emissions as fuel-cell cars powered by hydrogen made from natural gas. The difference is that diesel-hybrid technology is available today.

So why are diesel hybrids taking so long to appear on the roads? Hybrid diesels impose a double price premium, explains Lindsay Brooke, an analyst at CSM Worldwide. Combining a diesel engine, (which costs around $2,000 more than a petrol engine) with a hybrid powertrain (which adds another $3,000 or so) would make for an expensive proposition. Systems to treat the exhaust would impose further costs. The prospects for diesels and diesel hybrids are particularly dim in America, where regulations in California (and, from 2007, nationwide) require diesels to be as clean as petrol-driven cars. Some progress has been made: particulate filters can now eliminate more than 90% of diesel soot. But traps for nitrogen oxides remain a challenge.

The car of the future, today

Hydrogen fuel-cell vehicles promise to be the cleanest mode of transportation, eliminating harmful tailpipe emissions altogether. But despite much publicity, and the fact that most carmakers are working on the technology, fuel-cell cars will not appear in significant quantities any time soon. America's National Academy of Sciences, which advises the government on new technologies, recently estimated that the transition to a "hydrogen economy" will probably take decades, since many challenges remain—in particular, how to produce, store and distribute hydrogen in sufficient quantities.

Hybrid cars, however, offer many of the benefits of fuel-cell vehicles, with the huge advantage that they are available now. Moreover, as the success of the Prius shows, people will actually buy them. The beauty of petrol-electric hybrids is that they do not require any changes in driver behaviour or the fuel-delivery infrastructure.

Rather than being mere stepping-stones on the way to the hydrogen cars of the future, petrol-electric hybrids are likely to be around for years, if not decades, to come. When and if fuel-cell cars become available down the road, they may not replace hybrids, but instead are likely to be descended from them, since they require many of the same components, from control systems to motors. As Joseph Romm, director of the Centre for Energy & Climate Solutions, a non-profit organisation based in Arlington, Virginia, puts it, "hybrids are almost certainly the platform from which all future clean vehicles will evolve." ■

Move over, Big Brother

Security: Privacy advocates have long warned of states spying on citizens. But technology is, in fact, democratising surveillance

LIVING without privacy, even in his bedroom, was no problem for Louis XIV. In fact, it was a way for the French king to demonstrate his absolute authority over even the most powerful members of the aristocracy. Each morning, they gathered to see the Sun King get up, pray, perform his bodily functions, choose his wig and so on. One reported in 1667 that there "is no finer sight in the world than the court at the *lever* of the King. When I attended it yesterday, there were three rooms full of people of quality, such a crowd that you would not believe how difficult it was to get into His Majesty's bedchamber."

Will this past—life without privacy—be our future? Many futurists, science-fiction writers and privacy advocates believe so. Big Brother, they have long warned, is watching. Closed-circuit television cameras, which are proliferating around the world, often track your moves; your mobile phone reveals your location; your transit pass and credit cards leave digital trails. "Light is going to shine into nearly every corner of our lives," wrote David Brin in his 1998 book "The Transparent Society". The issue, he argued, is no longer how to prevent the spread of surveillance technology, but how to live in a world in which there is always the possibility that citizens are being watched.

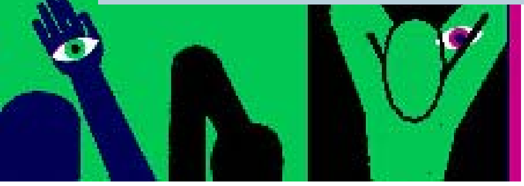
But in the past few years, something strange has happened. Thanks to the spread of mobile phones, digital cameras and the internet, surveillance technology that was once mostly the province of the state has become far more widely available. "A lot has been written about the dangers of increased government surveillance, but we also need to be aware of the potential for more pedestrian forms of surveillance," notes Bruce Schneier, a security guru. He argues that a combination of forces—the miniaturisation of surveillance technologies, the falling price of digital storage and ever more sophisticated systems able to sort through large amounts of information—means that "surveillance abilities that used to be limited to governments are now, or soon will be, in the hands of everyone."

Digital technologies, such as camera phones and the internet, are very different from their analogue counterparts. A digital image, unlike a conventional photograph, can be quickly and easily copied and distributed around the world. (Indeed, it is easier to e-mail a digital image than it is to print one.) Another important difference is that digital devices are far more widespread. Few people carry film cameras with them at all times. But it is now quite difficult to buy a mobile phone without a built-in camera—and most people take their phones with them everywhere. According to IDC, a market-research firm, 186m camera-phones will be sold this year, far more than film-based cameras (47m units) or digital cameras (69m units) combined.

The speed and ubiquity of digital cameras lets them do things that film-based cameras could not. In October, for example, the victim of a robbery in Nashville, Tennessee, used his camera-phone to take pictures of the thief and his getaway vehicle. The images were shown to the police, who broadcast descriptions of the man and his truck, leading to his arrest ten minutes later. Other similar stories abound: in Italy, a shopkeeper sent a picture of two men who were acting suspiciously to the police, who identified them as wanted men and arrested them soon afterwards, while in Sweden, a teenager was photographed while holding up a corner shop, and was apprehended within an hour.

Watching your every move

The democratisation of surveillance is a mixed blessing, however. Camera-phones have led to voyeurism—and new legislation to strengthen people's rights to their own image. In September, America's Congress passed the "Video Voyeurism Prevention Act", which prohibits the photography of various parts of people's unclothed bodies or undergarments without their consent. The legislation was prompted both by the spread of camera-phones and the growing incidence of hidden cameras in bedrooms, public showers, toilets and locker rooms. Similarly, Germany's parliament has passed a bill that outlaws unauthorised photos ▸▸



"The surveillance society is on its way—but not in the form that privacy advocates imagined."

within buildings. In Saudi Arabia, the import and sale of camera-phones has been banned, and religious authorities have denounced them for "spreading obscenity". A wedding in the country in July turned into a brawl when one guest started taking pictures with her phone. South Korea's government has ordered manufacturers to design new phones so that they beep when taking a picture.

There are also concerns about the use of digital cameras and camera-phones for industrial espionage. Sprint, an American mobile operator, is now offering one of its bestselling phones without a camera in response to demands from its corporate customers, many of which have banned cameras in their workplaces. Some firms make visitors and staff leave camera-phones at the entrance of research and manufacturing facilities—including Samsung, the South Korean company that pioneered the camera-phone.

Cheap surveillance technology facilitates other sorts of crime. Two employees at a petrol station in British Columbia, for example, installed a hidden camera in the ceiling above a card reader, and recorded the personal identification numbers of thousands of people. They also installed a device to "skim" account details from users as they swiped their plastic cards. The two men gathered the account details of over 6,000 people and forged 1,000 bank cards before being caught.

In another case, a man installed keystroke-logging software, which monitors every key pressed on a computer's keyboard, on PCs in several Kinko's copy shops in New York City. (Keystroke-logging software is sold for use by businesses to monitor their employees, or by parents who wish to monitor their children's activities online.) This enabled him to remotely capture account numbers and passwords from over 450 people who rented the terminals, and to siphon money out of their bank accounts.

Surveillance is a two-way street

But the spread of surveillance technology also has its benefits. In particular, it can enhance transparency and accountability. More and more video cameras can be found in schools, for example. Web-based services such as ParentWatch.com and KinderCam.com link to cameras in hundreds of American child-care centres, so that parents can see what their offspring (and those looking after them) are up to. Schools are also putting webcams in their classrooms: one American school district has plans to install 15,000 such devices for use by security personnel (and, perhaps one day, parents). And tech firms such as Google have put webcams in their staff restaurants, so employees can delay going to lunch if they see a long queue.

Steve Mann, a professor at the University of Toronto, calls the spread of citizen surveillance "sousveillance"—because most cameras no longer watch from above, but from eye level. Instead of being on top of buildings and attached to room ceilings, cameras are now carried by ordinary people. The video images of Rodney King being assaulted by police officers and the horrific pictures of prisoner abuse from the Abu Ghraib jail in Iraq are the best known examples. But as Mr Mann and his colleagues organised the first "International Workshop on Inverse Surveillance" in April, there was no shortage of reports on other cases: in Kuwait, a worker took photos of coffins of American soldiers being loaded on to a plane; in New Jersey, a teenager scared off a kidnapper by taking his picture; in Strasbourg, a member of the European Parliament filmed colleagues making use of generous perks.

Camera-phones could have a profound effect on the news media. Technologies such as newsgroups, weblogs and "wikis" (in essence, web pages which anybody can edit) let people distribute images themselves, bypassing the traditional media, notes Dan Gillmor, a journalist, in his recent book "We the Media". Camera-phones make everyone a potential news photographer. Unsurprisingly, old media is starting to embrace the trend. The San Diego Union-Tribune recently launched a website to gather camera-phone images of news events taken by their readers, and the BBC also encourages users of its website to send in pictures of news events.

Companies and governments will have to assume that there could be a camera or a microphone everywhere, all the time, argues Paul Saffo of the Institute for the Future. Unsafe conditions in a factory or pollution at a chemical plant are harder to deny if they are not just described, but shown in photos and videos. Animal-rights activists, for instance, operate online multimedia archives where people can store and view graphic images from chicken farms, slaughterhouses and fur factories. Such material can cause outrage among consumers, as was the case with videos of dolphins caught in tuna nets.

Last year, a German member of parliament was caught photographing a confidential document of which only a few copies were handed out (and later collected) at a background meeting on health-care reform. Some Berlin politicians are said to let reporters eavesdrop on fellow parliamentarians by calling them right before an important meeting—and then failing to hang up, in effect turning their phones into bugs.

In November 1996, Senegal's interior minister was caught out when he admitted that there had been fraud in a local election, but failed to notice that a bystander was holding a mobile phone with an open line. The election was annulled. In the same country's presidential election in 2000, radio stations sent reporters to polling stations and equipped them with mobile phones. The reporters called in the results as they were announced in each district, and they were immediately broadcast on air. This reduced the scope for electoral fraud and led to a smooth transfer of power, as the outgoing president quickly conceded defeat.

The social consequences of the spread of surveillance technology remain unclear. Mr Brin suggests that it could turn out to be self-regulating: after all, Peeping Toms are not very popular. In a restaurant it is generally more embarrassing to be caught staring than to be observed with crumbs in your beard. "A photographically 'armed' society could turn out to be more polite," he suggests, referring to an American aphorism that holds "an armed society is a polite society". Alternatively, the omnipresence of cameras and other surveillance technologies might end up making individuals more conformist, says Mr Brin, as they suppress their individuality to avoid drawing too much attention to themselves.

The surveillance society is on its way, just as privacy advocates have long warned. But it has not taken quite the form they imagined. Increasingly, it is not just Big Brother who is watching—but lots of little brothers, too. ■

In praise of P2P

Computing: Despite the legal wrangles over music piracy, peer-to-peer technology has many uses and is here to stay

IMAGINE an ideal global information-storage system. It would have to be huge, capable of delivering any one of millions of files, some of them of enormous size, to anywhere in the world within moments. It would have to be self-configuring and self-healing, rather than centrally controlled, to ensure there was no single point of failure. And it would have to be secure, capable of supporting millions of users, while resisting constant assault both from physical attacks on its infrastructure and from malicious software circulated within the network.

Such a system sounds highly desirable, particularly when compared with the internet, which has become a piece of critical economic infrastructure but is beset by constant security scares and can become clogged up if too many users try to do the same thing at once. Yet this ideal system already exists, in the form of peer-to-peer (P2P) file-sharing networks such as eDonkey and KaZaA.

The technology, which is used by millions of music lovers to download songs—usually infringing copyrights—is reviled by the entertainment industry. In America and Europe, music and film companies are using the courts and lobbying for new laws to outlaw P2P technology. In October, trade groups representing the entertainment industry went so far as to petition America's Supreme Court to consider whether makers of P2P software should face "secondary liability" for copyright infringement by their users. Officials at America's Department of Justice have even suggested that using P2P supports terrorism. The technology is also condemned as a distribution system for illegal pornography.

Yet rather than being demonised, there are good reasons why the technology should be celebrated—and its benefits more widely studied and exploited. Arguing that the internet's robustness and security could be improved using technology generally associated with music piracy might seem strange, admits Yochai Benkler of Yale Law School, who raised the idea in a recent paper, but the suggestion is a tribute to "how robust these systems are". P2P networks have, after all, withstood years of legal, technical and physical assault, but still work.

The widespread equation of P2P with piracy has obscured the fact that the same technology is also being constructively applied in all sorts of fields, from content distribution and internet-routed phone calls to distributed storage and search. Peer-to-peer technology is emerging as a powerful new approach to building large-scale computer systems, regardless of the entertainment industry's legal efforts.

Technically, "peer-to-peer" refers to a computer's ability to communicate directly with other computers running the same software, without having to go through intermediaries. While this might appear to describe the internet itself, the reality is slightly different. Although the internet was originally designed to be decentralised, it has evolved into more of a hub-and-spoke system. Personal computers at the edge of the network connect to powerful servers in the centre to do things such as send e-mails or retrieve web pages. What was once a network of equals, made up of machines that were both producers and consumers of content, became something that "looked like television with packets," says Clay Shirky, a technology consultant.

Strength in numbers

Peer-to-peer connects computers directly—and once enjoined, personal computers can do things they are unable to do alone. Most P2P systems let users pool resources, be it processing power, storage capacity or bandwidth. In the case of music file-sharing, users are, in effect, creating an enormous shared filing system from which they can all retrieve songs. Over half of all internet traffic is now generated by peer-to-peer applications, according to CacheLogic, a P2P network-services company in Britain. Figures from BigChampagne, an internet-research firm in Beverly Hills, California, suggest that at least 10% of the content on P2P networks is legal, and does not violate the entertainment industry's copyrights.

The most active P2P system, accounting for an estimated 35% of all internet traffic according to CacheLogic, is called BitTorrent. It is an open-source software project that is free to use and enables very large files to be stored and retrieved efficiently at essentially no cost. Though it is used for pirated music, it comes into its own when distributing really large files such as movies, games and large pieces of software such as the Linux operating system—things that would otherwise be very costly for companies or individuals to make available for download.

Part of BitTorrent's success stems from the way it creates incentives for users to give as well as to take. A study in 2000 on one P2P network showed that almost 70% of users never shared files, and around

"The equation of P2P with piracy has obscured its many virtuous uses."

half of the files available were offered by just 1% of users. BitTorrent is designed to remedy this. It rewards those who share files with others by increasing the download rate at which generous users can receive content, explains Bram Cohen, the system's creator. More sharing means there are more potential locations where copies of a given file are located, which in turn increases access speed. BitTorrent uses a technique called swarming, in which files are broken into small chunks that are then passed between peers. Two peers downloading the same file at the same time can also swap chunks they have already received from other peers, increasing the efficiency of the transfer.

P2P's ability to distribute content efficiently has prompted a number of initiatives to establish legal P2P distribution services. LionShare, devised at Penn State University, uses a file-sharing program to encourage the exchange of academic information around the world. Then there is Kontiki, a commercial P2P outfit, which was recently evaluated by the BBC as a way to distribute programmes online. Kontiki places portions of large files on participating PCs throughout the network, to increase performance. Computers at the edge of the network, not just big servers at the centre, thus help in the storage and sending of the file. Similarly, Red Swoosh runs a P2P network for legal file-sharing of copyrighted content. "Let's take this technology that the entertainment industry is scared of, and turn it into something that they want," says Travis Kalanick, Red Swoosh's chairman. Despite the legal rhetoric, the two sides are, in fact, quietly negotiating.

One organisation that relies on P2P content distribution is the Internet Archive, a public, non-profit library of digital content co-founded by Brewster Kahle, a technology entrepreneur based in San Francisco. The archive uses five different P2P systems so that it can distribute audio and video "without going broke on bandwidth fees", says Mr Kahle. Without P2P, he says, only big companies would be able to afford to distribute large amounts of video online. P2P allows individuals and non-profit initiatives like his to distribute multimedia content too.

Using a peer-to-peer approach for content distribution stands the traditional limitations of the internet on its head, says Cory Doctorow of the Electronic Frontier Foundation, a high-tech lobby group. P2P does away with the "popularity penalty" that makes desirable content

difficult to obtain. With systems such as BitTorrent, the more a file is in demand, the more available it becomes. Content automatically ends up being stored close to the users who request it, improving the performance of the system.

But there is more to P2P than just distributing information efficiently. The same approach has inspired other applications. The creators of KaZaA, a popular P2P network mainly used to share music and video files, sold the company and set up Skype, a free internet-telephony service that uses a similar P2P architecture to route voice calls rather than music files from one PC to another. (Both KaZaA and Skype rely on the idea that some computers should appoint themselves as "supernodes", akin to voluntary traffic police, to ensure a smooth flow of data between other machines on the network.)

Another company, Groove Networks, uses a P2P-like system to provide shared workspaces for online collaboration: it allows, for example, more than one person to edit the same document simultaneously. P2P is also an obvious way to construct an internet-based file back-up service. And why not build a search engine based on P2P principles that recommends documents based on other users' preferences, much as Amazon recommends books based on other customers' purchases? "P2P is a perfectly natural evolution of the internet—in fact, a return to the original style and usage that the creators of the internet really had in mind," explains Ian Clarke, the founder of FreeNet, a P2P network that provides anonymity in order to bypass censorship.

Appropriately enough given the internet's military origins, the American army is also looking into the uses of P2P technology on the battlefield, to improve the "situational awareness" of its troops. Rather than distributing information in a hierarchical manner, it might make more sense for soldiers to exchange data using a P2P approach. (Some military radios already work in this way: they use a self-configuring technique called "mesh networking", where each radio also acts as a relay to interconnect other nearby radios.)

With all this resource-sharing and decentralisation going on, one might be tempted to think the internet is finally becoming one big happy community, as some of its more optimistic visionaries had hoped. Alas, bursting that bubble is Bernardo Huberman, the director of the Information Dynamics Lab at Hewlett-Packard Laboratories. "P2P is an architecture—what we need is a market mechanism," he says. That way, P2P users can be properly compensated for sharing their computing cycles, storage capacity or bandwidth with others. His researchers have, for example, devised a system called Tycoon, which auctions off spare computing capacity. This sort of approach, he argues, is vital if P2P applications are to develop from today's volunteer systems into something big firms might want to adopt. "If you noticed coins dropping into your machine, you might be tempted to do that," he says.

Peer pressure

The danger is that the legal efforts to stamp out P2P's illegal uses might also blight the prospects for its virtuous uses, by hindering investment. In the case of Napster, once the most popular P2P music-sharing service, a legal ruling in 2001 temporarily shut the company down, and its venture-capital backers were sued for vicarious liability. This dampened investors' willingness to fund other firms developing P2P-related technology, even though there are now plenty of examples of legal uses of P2P.

Meanwhile, the technologists are continuing to write their software code. "P2P doesn't need a case made in its favour—it's just technology. Once it's out of the box you can't put it back in the box, and that's the end of that," says Mr Cohen—speaking, as you would expect of a P2P pioneer, over Skype's P2P telephone network. ■

The journey of the sorcerer

Craig Venter, the man who led the private effort to sequence the human genome, still has plenty of new ideas up his sleeve

IT IS an immodest ambition from a man whom even his best friends would rarely accuse of modesty. Craig Venter's current venture is a scheme to create an artificial lifeform. He and his team at his eponymous institute, in Rockville, Maryland, have already synthesised a working virus from off-the-shelf (or, at least, out-of-the-catalogue) chemicals. But viruses do not have their own metabolisms, so not everybody counts them as truly living beings. Making a bacterium (or, at least, the genome of a bacterium) would be one of the last nails in the coffin of vitalism—the curiously persistent idea that there is something more to biology than mere physics and chemistry.

It is not just curiosity that drives the project, though. Dr Venter believes such a cell, built around the minimum genome necessary for life, would be an important tool in biotechnology. A stripped-down cell could have extra biochemical pathways engineered into it, to make useful chemical products such as drugs and fuels, without any fear that the cell's resources would be diverted to other, useless, tasks. Finding those extra biochemical pathways is also on his agenda.

Another of Dr Venter's characteristics is an ability to mix business with pleasure. To this end he has fitted out his racing yacht, *Sorcerer II*, as a laboratory, and is sailing round the world collecting samples. These are flown back to Rockville to undergo "whole ecosystem" genome analysis—a process that tries to extract and analyse DNA from all the bacterial species in the sample. Since bacteria are the most abundant form of life on Earth, he hopes this process will eventually reveal most of the genes on the planet.

From gadfly to guru

Dr Venter first came to public attention in 1991. At the time, he was working in the National Institutes of Health (NIH), America's huge, federal medical-research establishment. The Human Genome Project, which planned to chew its way through all 3 billion genetic "letters" that carry the instructions for making a human being, was just getting going. But all geneticists knew that only a few of those letters—probably less than 5% of them, actually constituted the genes. Dr Venter produced a short-cut that enabled people to get directly at the genes. He did not actually invent the idea of making so-called complement DNA (cDNA), by copying the messenger molecules that carry genetic information from the cell nucleus, where the genome resides, to the protein-making machinery in a cell's periphery. But he was the first person to make it work routinely.

His technique caused a kerfuffle for two reasons. First, the biologists behind the Human Genome Project feared that if the genes could be plucked so easily from the dross, then the effort to sequence all 3 billion letters would be abandoned by parsimonious politicians. Though the non-gene part of the genome is often dismissed as mere "junk DNA", they felt (correctly) that at least some of it must be biologically important, so disentangling the whole lot was therefore necessary.

That turned out to be an idle fear. The importance of the whole genome was quickly recognised from on high, and the money kept flowing. But the second worry connected with the technique stirred up a hornet's nest whose swarm followed Dr Venter for a decade. At the behest of the NIH's lawyers, his first set of cDNAs were sent off to the patent office. DNA sequences had been patented before, so there were precedents for doing this. But the patents were for whole genes, and for genes that had solid, useful functions—namely drug production.

Dr Venter's cDNA sequences were not even whole genes.

"How long will it take to make a synthetic bacterial genome? An announcement could come as soon as next year."

The trick that allowed him to succeed where others had failed was that he copied only a fragment of a gene—the longest fragment that a DNA-sequencing machine could analyse in one go, which is well short of the length of most full genes. These fragments enable researchers to locate genes on chromosomes. Also, enough of them taken from different parts of a messenger molecule can allow a gene to be patched back together. So they certainly had enough utility for it to be worth asking the patent office if they counted as intellectual property. But many of Dr Venter's fellow biologists were outraged by the whole idea of patenting DNA in bulk, and they made their opinions abundantly clear.

In the end, the NIH withdrew its patent applications. But the affair both poisoned relations and gave Dr Venter a glimpse of a wider world. Shortly afterwards, he withdrew to set up TIGR, the Institute for Genomic Research. Thus began his quest to marry academic and commercial research in what he saw as a return to a more 19th-century way of doing things that had prevailed before the split between pure and applied science became so clear-cut.

The money for TIGR came from Wallace Steinberg, a venture capitalist. The idea was to use the CDNA technique to look for interesting genes. The commercial side of the operation would have a period of grace to examine them with a view to patenting and exploitation. The academic side could then publish interesting findings in scientific journals. It might have worked. But the commercial side, which was incorporated into a firm called Human Genome Sciences (HGS), was led by William Haseltine, a man with an ego as large as Dr Venter's, but a far more single-minded money-making agenda. The two men fell out, and the two sides of the organisation got a divorce; HGS set up its own, internal research arm.

A shotgun wedding

That, paradoxically, was the making of Dr Venter. For it freed him to try a new idea. At the time—the mid 1990s—DNA sequencing was a painstaking affair that involved breaking an organism's genome into pieces, growing the pieces in bacteria or yeast cells, extracting them again, breaking them up still further, feeding the small bits into a sequencing machine, and then trying to put the whole jigsaw puzzle back together in reverse. Dr Venter suspected it could be done much faster by shredding entire genomes in a single step, sequencing the bits, and using a computer to fit those bits back together. Again, the idea had been kicking around for a while. But with the aid of a biologist called Hamilton Smith, he made it work.

The technique in question was called whole-genome shotgunning. It revolutionised the field. Its first fruits were the genomes of bacteria. Indeed, one of Dr Venter's favourite anecdotes is how he received a letter from a funding committee denying his application for money to deploy the technique at precisely the moment he was putting the finishing touches to a paper describing the first bacterial genome ever sequenced. But it occurred to Dr Venter that larger genomes than those of germs might fall to the new technology. And, by a lucky co-incidence, the bosses of PerkinElmer, the firm that made the DNA-sequencing machines used by Dr Venter and most other workers in the field, were having similar ideas.

The resulting collaboration was called Celera Genomics, and its goal was to produce a privately financed version of the human genome's sequence. If genomic officialdom had had qualms about the patenting of CDNA, it had paroxysms at the idea that the entire human genome might somehow fall into private hands. The result was a massive reorganisation and speeding up of the public Human Genome Project, with a view to putting huge quantities of the sequence into the public domain, and so beyond the reach of Celera's patent lawyers.

In fact, Dr Venter had never intended to patent more than a few hundred crucial (and, he hoped, ultimately profitable) genes. Indeed, some accounts from inside Celera at the time suggest he was almost as much at loggerheads with the firm's lawyers as were the public project's biologists. As in the case of TIGR, the biologist and the businessman were uncomfortable in the same skin. Instead, what he had in mind was a business that would deliver "value-added" biological information to drug companies and other researchers, much as Bloomberg packages and delivers financial data.

The outcome of the race between Celera and the public project was a politically brokered tie in which Dr Venter and his rivals shared a platform with President Bill Clinton. It was good publicity. But in the end, Celera failed. It delivered the genome (one of the six individuals sequenced being Dr Venter himself), but failed to deliver profits. The added value which it promised was not deemed valuable enough by potential customers and Dr Venter, in the time-honoured phrase of public-relations offices everywhere, "left to pursue other interests"—the main ones being synthetic biology and whole-ecosystem sequencing.

How long it will take to make a synthetic bacterial genome remains to be seen, though an announcement could come sometime next year. But whole-ecosystem analysis is already yielding staggering results. The technique is a logical extension of whole-genome analysis. The DNA in a water sample is extracted, shredded and sequenced, and the sequences assembled by computer. If the technique works properly, it will sort out the individual bacterial genomes without there ever being a need to culture the species to which those genomes belong.

Towards the planetary genome

The need to culture has held bacteriology back since its earliest days. Culturing bacteria is time-consuming, and many bacteria do not thrive in captivity. Bacteriologists knew that, of course, but they could only guess how little they knew. And the answer seems to be that they knew almost nothing. Before the first collecting jar was dipped in the water in *Sorcerer*'s wake (off the coast of Bermuda, as it happened), about 5,000 species of bacteria had been classified. That single sampling site, Dr Venter reckons, yielded 47,000 new species, and the other sites (one every 200 nautical miles, or 370km, between Bermuda and Sydney, via the Pacific) have been just as productive. Altogether, Dr Venter thinks he has identified some 5m new genes. Not yet a genome for the planet. But a start. ■