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## Networking and wireless

### Analysis: Digital dividend and spectrum re-allocation

#### At a glance

- The radio spectrum is allocated to particular uses and regulated by national and international bodies.
- Digital technology can make much more efficient use of existing spectrum.
- DVB-T and DAB are the major digital technologies for television and radio, respectively, in the UK.
- Analogue to digital switchover will release spectrum as a 'digital dividend', which can be used for additional or innovative services.
- Parts of the spectrum, especially 800-900MHz, are seen as particularly suited to delivery of mobile broadband services, especially to remote 'not-spots'.
- The authors of the *Digital Britain* report and Ofcom have set an agenda for digital radio and mobile spectrum reallocation in the UK.

#### The value of wireless spectrum

The 'wireless' spectrum is part of the much broader electromagnetic spectrum that encompasses microwaves, light, X-rays and similar phenomena. Fifty years ago only a few radio and television stations were available, but broadcast and specialised wireless services have mushroomed in the last couple of decades, putting pressure on the available bandwidth. Wireless devices in the home avoid all kinds of cable clutter, while commercial providers can considerably reduce the cost of fixed communications infrastructure and there is competition from the emergency services, the military, hobbyists and others. The UK 3G spectrum auction raised £22 billion in 2000 and the [EU estimates](#) that the annual value of services that depend on the radio spectrum across the continent is €200 billion.

There has been a considerable shift in technology, as analogue systems give way to digital and the underlying service design moves from broadcast to interactive. Ofcom - the independent organisation tasked by statute with allocating the UK's civil spectrum - admits that the current model for television is based on the needs of the late 1950s. It is currently engaged in the [Digital Dividend Review](#), examining how to make better use of spectrum released by the introduction of new television technology.

Proposed changes have to take account of legacy applications and equipment, but they could open up considerable areas of spectrum for use by new and improved services, expanding the hardware market and incomes of mobile operators. However, there is a danger of creating confusion among consumers and anger if they are forced to buy new hardware, or where services are restricted, moved or discontinued.

Students will be impacted as members of the public and as learners - devices will need to be upgraded and services may cease or appear in a new, unexpected guise. Educational services will need to take account of the new broadcast environment,

especially as radio spectrum becomes more important as learning moves towards an 'anytime, anywhere, any device' model.

### **A broad view of wireless spectrum**

A [simple video guide](#) to the radio spectrum is available from the EU and the BBC has provided a [more detailed overview](#). The current allocation of spectrum in the UK is outlined in the [UK Frequency Allocation Table](#) from Ofcom. The structure is a complex interweaving of legacy functions, niche products and spectrum reused for modern applications, so it is difficult to summarise. The relevant part of the spectrum breaks down into three broad bands:

- **VHF** (very high frequency, 30-300MHz). This covers FM (86-108MHz) and DAB (218-231MHz) radio in the UK, and a variety of other communication uses.
- **UHF** (ultra high frequency, 300MHz-3GHz). This encompasses most modern television services (470-854MHz), many Wi-Fi networks (2.4GHz), mobile telephone transmissions (around 900, 1800 and 2100MHz) and a host of other uses.
- **SHF** (super high frequency, 3GHz-30GHz). This includes many satellite transmissions (see [TechNews 05/09](#)), radar and microwave communications applications.

Spectrum bands are divided into smaller 'channels' which are designed with particular purposes in mind, although some uses may combine several channels. For example, UHF television uses 8MHz channels whereas an FM radio station only needs 300KHz. Actual transmissions involve a 'carrier signal' that is manipulated using modulation techniques to represent the data to be sent.

A complex of international, EU and national regulators controls the use of radio spectrum through treaties, directives and Acts of Parliament, as indicated by Ofcom's [Licensing Policy Manual](#).

### **The digital dividend**

Use of higher frequencies and considerable advances in technology have underpinned the development of digital television, which encodes data as 0s and 1s, rather than infinite analogue variations on the carrier signal. Digital terrestrial television (DTT) can compress far more data into the same radio channel, permitting whole groups of stations (including radio stations) to be woven together ('multiplexed') and broadcast using the European DVB-T standards. Each multiplex covers several radio channels, but the number required in the UK will be cut from 46 to 32 once the analogue signal has been switched off in 2012, leaving a 'dividend' of 14 channels.

Ofcom's [Digital Dividend Review](#) has yet to reach final conclusions, but the following uses have been suggested for the freed spectrum:

- Improved mobile services, with higher quality video and greater interactivity
- Wireless broadband services

- Improved services in rural areas
- Advanced services to support major sporting events
- Additional television channels.

Digital channels can be received through Freeview receivers integrated in new televisions or set-top boxes, or are available as Freesat channels accessed using the similar satellite hardware as subscription services.

Further developments, which would require consumers to invest in new equipment to take advantage of improved or additional services, are in the pipeline. In April 2008, Ofcom [recommended](#) upgrading Multiplex B to MPEG-4 video encoding and the new DVB-T2 standard (expected to be ratified this month). The multiplex will eventually carry four HD television stations (or 15 standard definition services), with first broadcasts are planned for the Granada (northwest) television region later this year.

### **DAB**

Digital audio broadcasting (DAB), providing two national and 46 local multiplexes, is somewhat akin to DTT for radio. Depending on the quality of encoding, a single multiplex can transmit five to ten stations in a single 1.7MHz channel. Due to the way that the signal is encoded and the allowance in the signal structure for transmission delays caused by signals travelling several paths, DAB signals are delayed about 1.5 seconds compared to real time. The big advantage of this schema is that it allows signals from neighbouring transmitters to be aggregated in areas of weak reception and for the same channel to be reused nationally, [as explained by](#) Jim Lesurf, a retired senior lecturer from University of St Andrews.

The final [Digital Britain](#) report, published last month, recommends that all national UK radio broadcasts be converted to DAB by 2015. The FM frequencies released will be used for 'ultra-local' radio services previously found on AM channels. (It may be possible for educational services to be broadcast on these frequencies.) The efficiencies of digital broadcasting and the release of spectrum from the upgrade will release bandwidth for other, as yet undefined, purposes.

*Digital Britain* contains a range of recommendations and targets to ensure a smooth transition to DAB, including accelerating access to DAB broadcasts and initiatives to involve motor manufacturers in installing capable equipment. The proposal has [caused some disquiet](#), not least due to the sudden redundancy that will be imposed on existing hardware. Other concerns have included lower audio quality on many DAB channels and the increased complexity (and thus power consumption and cost) of both transmitting and receiving equipment.

### **Mobile spectrum**

Mobile spectrum is highly prized by the operators, especially that owned by O2 and Vodafone around 900MHz. These frequencies have better propagation characteristics - able to travel further and are less influenced by awkward terrain and buildings - compared with 1800 and 2100MHz holdings. In parallel with *Digital Britain*, Ofcom have been running a review on mobile spectrum reorganisation.

There is an intention that spectrum released from television holdings around 800MHz be auctioned off for mobile and other services extending across the whole of the EU, giving manufacturers and operators economies of scale to develop improved or innovative equipment and services. *Digital Britain* envisages that cross-trading some of the 900MHz spectrum could be used to improve delivery options for broadband services to the 'not-spots', as part of the proposed 2Mbps 'universal service commitment' by 2012. There will also be an auction of 2.6GHz spectrum, suited to fast, urban, mobile data networks.

Ofcom's 'Independent Spectrum Broker' [had suggested](#) that O2 and Vodafone be required to do a one-for-one swap between channels owned in the 900MHz region, if they were successful in bidding for 800MHz spectrum, allowing the other operators access to these frequencies. *Digital Britain* has proposed more lenient terms on both allocation and total spectrum ownership caps, but nothing has been finalised. As [noted by PC Pro](#), these decisions will have knock-on effects on the availability of fast LTE (long term evolution) '4G' mobile services.

### **The future**

Digital broadcast services are rapidly gaining ground, as [Ofcom research](#) has found that 9 out of every 10 UK homes now has at least one television or set-top box capable of receiving digital broadcasts and Freeview's managing director estimates that 60 per cent of homes will be able to access the HD service by the end of 2010. Consumers have recently caught the 'vision' for digital television, but it remains to be seen whether they will be equally persuaded by DAB. In *Digital Britain*, the Government is seeking to create certainty in the regulatory environment, but important issues have yet to be settled, especially in regard to use of the mobile spectrum. Once these immediate decisions have been resolved, it remains to be seen what services will be offered through the spectrum released by the digital dividend and other initiatives.

The market is moving rapidly on both the technological and regulatory fronts, which is creating its own problems. Significant transitions, such as a national switchover to DAB, require long lead times for infrastructure development, hardware design and installation, waste equipment disposal and raising consumer awareness. Despite Ofsted's research, [it is reported](#) that MoneySupermarket.com found that two thirds of consumers remained unclear about the television switchover and nearly a quarter claimed not to have suitable hardware.

## **Networking and wireless news**

### **New satellite services**

Tooway [has launched](#) a new broadband service delivered by satellite in competition with other services, such as [Astra2Connect](#) from Eurosat. The service is based on geostationary satellites whose orbit keeps them above the same point above the equator at an altitude of 35,786km. This distance introduces significant latency (delay) based on the speed of radio signals, which the company says it has mitigated through use of a performance enhancing proxy (PEP). Normal internet connections use transport control protocol (TCP) to ensure accurate transmission of data, but

TCP is based on low-latency wired connections. Performance enhancing proxies use techniques, such as spoofing the expected TCP acknowledgements, to ensure that each time 'window' is extended and more data is sent before a reply is required. The service is bi-directional, so no landline connection is required.

Tooway will be sold on by resellers, such as [Avonline](#). Their lowest monthly payment of £29.99 provides a downlink speed of 2048Kbps and uploads of 384Kbps for a data 'cap' of 1.2GB. If this cap is exceeded in any month, a fair use policy throttles further downloads for that month. The most expensive £99.99 per month 'Gold' service offers 6GB of data at the same connection speeds. To both of these must be added one-off equipment (£599) and installation costs (£200).

Satellite broadband can be complemented by satellite television and voice (VoIP) services, at an additional cost, to provide a 'triple-play' service. Tooway suggests that the round-trip latency of 600ms is adequate to deliver a voice service, although it is reasonable to expect users to perceive some delay, and gameplay for highly interactive games is likely to suffer from the lag. Eutelsat, who provide the infrastructure for Tooway, will be launching a new satellite in 2010 that is expected to boost download speeds to at least 4Mbps, although the latency problem will remain.

The European Commission [has allocated radio spectrum](#) to two companies who will provide mobile satellite services (MSS) across Europe. [Inmarsat Ventures](#) and [Solaris Mobile](#) will provide a platform for broadcast radio and television services and two-way communications (including consumer broadband) using S band (2 to 4GHz) frequencies for mobile equipment. Inmarsat intends to [launch its EuropaSat](#) geostationary satellite early in 2011 to provide these services across the EU, although both companies are expected to offer some services from late next year. This European agreement reserves spectrum across the continent, but specific services will still have to be approved by national regulators.

Due to its longer wavelength, S band has fewer problems caused by objects in the signal path of transmissions, compared to other satellite services, but direct satellite communication will still require a good view of the southern horizon. (See [TechNews 05/09](#) for details of other satellite broadband services and the technologies they use.) Although the operators have yet to provide much detail about their services, they can rely on ground-based components, which may open up opportunities to use satellites for backhaul to the core network and relay systems that will provide the final link to the mobile device. The 2GHz frequencies that have been allocated are close to those used by many 3G mobile telephone services, allowing production of handsets (using similar technology) that will be able to roam between satellite and terrestrial services.

In a separate development, Avanti Communications [has announced](#) that it has been awarded a €250,000 (approximately £220,000) grant by the European Space Agency towards preliminary design costs for its new Hercules satellite system, which will provide broadband coverage across the UK. Avanti suggests that the project could provide broadband coverage at speeds of 2Mbps to 50Mbps for some of the 2.5 million homes in rural Britain. The proposed system would complement and

extend the service to be offered from Avanti's HylasOne satellite, expected to be launched later this year.

These new services may offer possibilities for providing the Government's proposed 2Mbps Universal Service Commitment (USC) for broadband in rural areas, although such services will experience greater latency (delay) involved in signal transmissions across large distances and are likely to be more expensive compared to entirely ground-based solutions. Communication with geostationary satellites also requires a clear view of the sky near the horizon, which is often obscured in upland areas.

### **Final *Digital Britain* report published**

The Department for Culture, Media and Sport (DCMS) and the new Department for Business Innovation and Skills (BIS) have [launched](#) the final [Digital Britain](#) white paper. (The interim *Digital Britain* report was covered in [TechNews 03/09](#).) The report reviews the current 'digital marketplace' across the broad spectrum of digital media, broadcasting, content development, the digital economy, access to online services, digital and creative skills, media literacy, e-safety and security, and e-government services.

The report states that the 'Digital Britain sectors' account for nearly a tenth of national turnover (chapter 1, paragraph 7) and that,

'We are at a tipping point in relation to the online world. It is moving from conferring advantage on those who are in it to conferring active disadvantage on those who are without.' (Chapter 1, paragraph 18).

Specific new proposals include (with paragraph numbers from Chapter 1 in square brackets):

- A 2Mbps 'Universal Service Commitment' (USC), as set out in the interim report, to be in place by 2012 [23]. £200 million will be set aside from savings from The Digital Switchover Help Scheme [24] to help fund this commitment, although further funding will be needed from the industry and other sources.
- A £6 annual levy (50p per month) on all land line connections to be aggregated into a Next Generation fund [30]. This will subsidise projects to connect the majority of the 'final third' [26] of households to 'next generation' broadband networks (with typical speeds of 40Mbps or greater) by 2017. The 'final third' are those premises still expected to be served by current broadband technologies once BT, Virgin and other providers have rolled out fast connections across the rest of the network. The levy is expected to yield £150-175 million per annum, although commentators [have questioned](#) the extent to which this could deliver significant infrastructural improvements.
- A range of measures is proposed around reallocation of radio spectrum to release capacity for fast mobile broadband connections. There should also be improvements to broadband access on trains and new coverage for the London Underground [31].
- A mandated switchover to digital audio broadcasting (DAB) for all the main national radio networks by 2015 [39].



- Measures to give rights holders a route to civil action (as a last resort) against people illegally sharing copyrighted material [46].
- A consultation on using a part of the Television Licence Fee to help deliver public service broadcasting commitments on channels beyond the BBC [55].
- The development of a 'Digital Life Skills Entitlement' for adults [20, 62 and Chapter 6 paragraph 33], delivered through up to 9 hours of online modules by a range of learning providers, including FE, Learndirect and centres run by unions.
- A programme for the 'Digital Switchover of Public Services'. As a result, the report states, 'online will become the primary means of access' [77], although there will be a safety net for those without online access.
- Central standards for procurement and sign-off on major IT projects, especially developments towards a 'G-Cloud' of government computing, maintained on and delivered through the internet [78].
- Martha Lane Fox to be the new Champion for Digital Inclusion [20] and Sir Tim Berners-Lee the convenor for a new panel to look at better use of public data [72].
- Many of the actions in the report will be down to Government and Ofcom, but it suggests the formation of a new Digital Delivering Agency [81].

Implementation of the proposals in *Digital Britain* should have significant impact on both students and adult learners. The universal service commitment will make home access to learning platforms and real time reports a realistic prospect for nearly every household, while many learners may be able to use online materials through improved mobile broadband connections. However, the slightly increased cost of landline connections could encourage more households to adopt a mobile-only telephone connection, reducing the likelihood of some reluctant users having a viable broadband service.

### **Notspots are not just rural**

Lord Carter's *Digital Britain* report is expected to set a minimum 2Mbps universal service commitment (USC) for providing broadband across the UK, but significant 'not-spots' exist where it is difficult to provide connectivity. People generally envisage these areas as rural, where population density, ruggedness of the terrain or underlying bedrock make it more difficult - financially and technically - to connect people to an exchange with 2Mbps capability. Lack of bandwidth hampers delivery of video content and, increasingly, the data underpinning modern web applications. In addition to degrading entertainment applications, inadequate bandwidth will constrain or prevent parental access, learners' ability to use learning platforms at home and remote working by teachers

A BBC [survey has found](#) that many of the 'not-spots' are surprisingly non-rural in character. The speed of an internet connection depends on the distance of a dwelling from the exchange, due to signal quality decaying over longer cable runs, as well as the equipment connected either end and the apparent maximum speed contracted to the customer. The BBC commissioned SamKnows to produce a map of the speeds likely to be experienced by broadband users across the country, with results showing that 50 per cent of household in Basingstoke are more than 6km

from an exchange (when 4km is generally considered the minimum for a 2Mbps connection) and a quarter of localities in Hampshire expected to get under 1Mbps. Even in areas sufficiently close to an exchange, the speed experienced by users may be under 2Mbps due to contention - 'competition' for the available bandwidth between users on the same connection.

'Not-spots' can also be social. Nearly three quarters of respondents surveyed by Ofcom's [Communications Consumer Panel](#) considered broadband an essential service, saying that everyone (including those on low incomes) should be able to access broadband at home. For those without connections, cost and perceived complexity were significant factors. [A post](#) on the Consumer Panel blog lists a range of applications that could reduce household expenditure or make life easier for those with broadband access. [BBC News reports](#) on comments from the head of the UK Online Centres suggesting that, of nearly a third of the population without a connection, half of those lacked skills or confidence to get online, as well as fearing that they could not afford the monthly charges. When one group was provided with broadband, nearly all agreed that the internet had made a difference to their lives and over half paid to maintain their connection after the end of the project.

An [Ofcom survey](#) found similar reasoning behind adults' decisions not to connect, although around one in five intended doing so within six months. The latter group were likely to be younger, employed and have children at home. However, Ofcom describes over two fifths of those without broadband as 'self-excluded', due to lack of interest or need. About the same number said they would not use the internet at home even if given the hardware and a free connection.

### **200Mbps broadband trial**

Virgin media [has announced a trial](#) for 200Mbps broadband in Ashford, Kent. The service will be based on its cable network, using the latest DOCSIS 3.0 protocol for broadband on cable television channels. DOCSIS 3.0, agreed by the International Telecommunications Union standards group in 2007, gives maximum downstream data rates (for 4 bonded channels) of 222Mbps in Europe. (Higher speeds can be delivered in Europe, compared to the US, as a wider frequency is allocated to each channel.) Maximum upload speeds are approximately half the download speed.

Virgin has selected 100 'lead adopters' and will monitor how they use the available bandwidth. Many servers on the internet cannot provide data at anything close to 200Mbps, so Virgin expects these households to combine streams among residents and use novel services. The company is working with suppliers to create innovative hardware and applications to take advantage of the available speed. Suggested uses include on-demand high definition and 3D television, remote surveillance and security, and video conferencing. Virgin is also looking to see how home networks perform under the high loads that could be generated.

Virgin Media is also considering how this service could be used by businesses. With appropriate quality of service guarantees, these speeds could prove attractive to some schools in areas that have access to cable services, although Virgin has yet to announce any plans to deliver commercial services using this bandwidth.

## JANET tests 100Gbps network links

JANET, the UK's research and education network, [has trialled](#) 100Gbps network links following a [successful programme](#) that upgraded the network core from 10Gbps to 40Gbps. Traffic predictions have suggested that 40Gbps will be inadequate in two or three years' time for the busiest circuits, so trials across a 103km fibre segment were carried out in conjunction with [Verizon Business](#) to prove that the key infrastructure could sustain higher bandwidths.

Optical fibre is prone to signal degradation (due to materials defects) that become more critical at higher speeds. A Nortel Adaptive Optical Engine, which employs techniques to compensate for these effects, was used to generate simultaneous 10Gbps and 40Gbps test traffic, using wavelengths either side of the 100Gbps carrier. The test, which deliberately introduced impairments to be electronically corrected at the receiving end, demonstrated that the network could be upgraded without having to lay new fibres.

Networks in most institutions, as well as wide area network links, are in danger of becoming congested due to transfers of larger data sets and use of increasing amounts of video.

## Nearly half of businesses could get 20Mbps ADSL2+

PC Pro [reports](#) that BT will offer a 20Mbps broadband connection to many of its business customers by the end of this year. The service, which BT estimates will cover 40 per cent of businesses, will be based on BT's upgraded 21CN (21st Century Network) exchanges. ADSL2+ is an enhanced form of ADSL that offers speeds up to 24Mbps, especially for premises located close to exchanges. BT does not expect end-users to experience the maximum speed, even near the exchange, especially as the service remains contended at 50:1 (so that 50 users could be sharing the same access point).

A number of other internet service providers offer ADSL2+ connections from 'unbundled' exchanges, where they can connect consumers direct to their own data networks. Fast internet connections support higher quality video services and allow more concurrent users to share the same bandwidth without a noticeable degradation in their service.

## Improving broadband from moving vehicles

Wireless internet connections from rapidly moving vehicles can be unreliable since the receiver travels between radio cells, through 'hot-spots' and negotiates handover when a stronger signal is detected. R2D2 is a new reception system, [invented by researchers](#) including engineers at NEC and Rutgers University in the US, that balances directionality and diversity.

Careful control of constructive interference between radio signals generated by multiple antennae can be used for 'beam forming', to direct a stronger 'composite' radio signal in a given direction, but this risks a break in transmission as a vehicle moves. The opposite strategy is to broadcast a weaker signal, which will reduce transmission speeds, to a diverse set of receivers. R2D2 dynamically adjusts the

balance between these two techniques as it moves between base station reception zones. R2D2 has a base station component that retransmits packets to the one with strongest reception, designated the 'anchor', while 'beam manager' software builds a database of signal strengths along frequented routes.

The trials conducted by the researchers suggest that the technology is significantly faster than alternatives. However, the current system is based on Wi-Fi (rather than the far more common 3G signals used by mobile phones), uses auxiliary transmitters mounted on car rooftops and has only examined large data uploads.

### **Users' mobile broadband speeds below 1Mbps**

Advertised 'maximum' broadband speeds for mobile phones and data dongles are often 3.6Mbps or 7.2Mbps, but users generally experience far lower actual speeds. [High-speed packet access](#) (HSPA) on today's networks can double theoretical maximum speeds (from 3.6Mbps) for standard 3G connections, while promising speeds 'up to' 42Mbps in future. However, except in ideal test conditions, these speeds cannot be achieved, due to interference, signal attenuation from atmospheric causes, multi-path effects (as signals 'bounce' around objects), distance from the base station and other factors. Further, error correction and other data overheads must be taken into account, while competition between users for bandwidth (contention) can rapidly degrade speeds at busy times.

Research group [Epitro](#) monitored a sample of UK mobile broadband connections and found that 'real world' speeds averaged out at just 0.9Mbps. Based on tests carried out by 1,300 users over five months, the analysts found that users received about a quarter of the advertised maximum bandwidth, although speeds rose by 11 per cent over the test period.

Mobile devices are being increasingly used in educational settings for delivery of learning activities and administrative uses, but continued access beyond Wi-Fi networks cannot be guaranteed. As this report shows, even where strong 3G signals are available, users may struggle to download information at 'acceptable' speeds. The 'universal service commitment' (USC) contained in the *Digital Britain* report relates to speeds experienced by users, so many mobile connections may fail to deliver this commitment under present conditions.

### **New Wireless Gigabit Alliance**

A group of well-known companies, including Intel, Microsoft, NEC, Nokia, Qualcomm and Samsung have formed a new [Wireless Gigabit Alliance](#) with the intention of developing a fast, short-range 'WiGig' specification to wirelessly connect devices at gigabit speeds. A number of initiatives, including [WirelessHD](#), have proposed 60GHz solutions for delivering high definition (HD) television and removing cable clutter. This unlicensed portion of the spectrum can deliver much higher data rates over short distances, compared to 5GHz technologies, but 60GHz signals are more readily absorbed by walls and other objects.

Mark Grodzinsky, an executive from Intel and the Alliance's marketing chairman, [is reported](#) as suggesting that the technology becomes part of a 'tri-band Wi-Fi',

combining the 2.4GHz, 5GHz and 60GHz bands as a unified set of solutions. In this scenario, Wi-Fi could deliver longer range connectivity and WiGig higher bandwidth at short distances, with the whole infrastructure tied together using standard internet protocols (IP).

The Alliance has released few technical details, but it has an ambition to connect a broad 'ecosystem' of in-home entertainment and communication devices. The new radio chipsets will be designed to fit easily into televisions and PCs, as well as much smaller devices like mobile phones and digital cameras. A first draft of their standard is expected by the end of this year with actual chips likely to appear within two years.

### **Virtual Wi-Fi**

Windows 7 will introduce native support for a Wi-Fi network adaptor to also be used as a virtual device. [A press report](#) indicates that wireless hardware (with suitably configured drivers) could be identified as two separate Wi-Fi adaptors, each of which could be connected to separate networks to be used for different purposes.

For example, the true hardware device could be used to connect a laptop to an access point and the virtual device to connect other Wi-Fi enabled hardware (such as a mobile phone, an MP3 player or an e-book reader) to the PC. This arrangement would make it much simpler to set up mobile devices, since only the host PC would have to be configured for each physical access point utilised. Another use would be to set up a direct Wi-Fi connection to a suitably equipped projector, to enable wireless transfer of image data to the device, while maintaining a separate wireless LAN connection. A third possibility would be a mesh network, where several PCs act as both a user of Wi-Fi services and as a virtual access point - data would be transferred between computers and (where an external connection was needed) flow onto the internet via a cabled or wireless connection attached to one of the machines. Mesh networks can reduce the number of connections to an access point and extend its effective range (as the data can 'hop' between machines as well).

Virtual Wi-Fi (or VWifi) was developed as a [Microsoft research project](#) that has lain dormant since 2006.

## **Multimedia**

### **Analysis: Gesture control**

#### **At a glance**

- Simple gestures, such as 'point and click' have been used since the introduction of graphical interfaces.
- Touch screen interfaces tend to mimic desktop paradigms and remain essentially two-dimensional in character.
- Multitouch interfaces are more complex to develop but enable a wider range of gestures.
- Camera-based recognition systems can detect three-dimensional movements to control applications.
- Gestures may appear to provide a more intuitive interface, but interpretation can depend on prior experience or cultural considerations.

- The entertainment industry is concentrating significant attention to developing new controllers based on a user's movements.
- Assistive technology that recognises more gestures may benefit disabled users.
- Widespread adoption of multitouch and gesture-based systems in education will depend on development of pedagogically valid activities.

### **What is a gesture?**

Gestures are intentional body movements designed to communicate with another person: a gesture may signal an intention, give a command, assist an explanation or express a feeling. Although we tend to think of hand movements in particular, gestures can include a shrug of the shoulders, kicking a stone or pulling a face.

A limited range of gestures has been used to control computers for many years since graphical interfaces began to take over from the command line. Each movement of the mouse is a gesture, even though constrained to actions like point, click, drag and hover. These gestures are abstracted into the capabilities of the hardware and combined with onscreen cues (buttons, menus and the like) to produce a response from a given application.

The entertainment industry is driving considerable development of gesture-based controls, in addition to the more specialised demands of military, medical and other customers. This article will give a range of examples, but there are many more technologies and companies involved than will be mentioned here.

### **Touch**

The gestures that can be used to communicate with a computer system tend to be constrained by the capabilities of the hardware. For many years alternative input devices, such as joysticks and tablets, have tended to mimic the same desktop paradigms used by the mouse and keyboard, without adding significant functionality - all that was needed was to add new drivers to the operating system.

Touch interfaces are not new, but improvements in hardware and manufacturing techniques have made them very much more common; they are found on supermarket tills, ticketing machines, mobile phones, satnav systems, interactive whiteboards (IWBs), tablet computers and a diverse range of other hardware.

Most systems could (until recently) only detect a single touch. Some, such as a passive grid of infrared beams and sensors, cannot distinguish which of the opposing corner pairs of a rectangle have been touched when there are two simultaneous contacts. However, systems that actively 'scan' the surface using some form of pulse, or that have individually addressed grid points or electrodes, can detect multiple touches.

### **Multitouch**

Multitouch screens particularly came to the public's attention with the Apple iPhone and the new set of gestures it introduced. These, including spreading finger and thumb to zoom in, or a 'pinch' to zoom out, may be [subject to an Apple patent](#), but

they demonstrate simple functionality added when a device can track the relationship between two or more points that have been touched.

Multitouch needs more complex processing, as well as a more sophisticated sensor array, which in turn requires faster processors and chipsets. A drop in price of all these aspects of multitouch-capable devices has made them an attractive business proposition. Analysts [ABI Research predict](#) that the whole touch screen market will grow to \$5 billion this year, while the price of the touch screen components is falling 10 per cent, year on year.

Camera technology is rapidly gaining ground for larger touchscreen applications. Microsoft Surface (and the similar SMART Table) can track and process multiple touches from groups of users. The cameras in some touch applications may simply track shadows cast on the display, but Surface uses detectors that pick up infrared light scattered by fingers and other objects. The touches must all be considered 'independent', as the hardware cannot know how many people are involved or where they are located, unlike the iPhone, which can assume that there is a single user.

Microsoft's next PC operating system, Windows 7, [will have multitouch](#) algorithms embedded in the controls for its user interface.

Most touch screens essentially remain 2D in character, which limits the range of gestures they can detect. Further, especially on the screen of a mobile device, a reasonable degree of fine motor control is required to operate many touch-enabled functions.

### **Gestures in 3D**

The third dimension expands the range of gestures that can be employed. Toshiba [has demonstrated](#) a television control system that invites the user to raise an arm to indicate that other gestures will be used, for example to change the volume or switch channels.

Developers of games control hardware are vying with each other to apply a wide range of body movements to control in-game action. Nintendo's remote control for its Wii console embeds gyroscopes and accelerometers that detect movement of the device through the air, plus an infrared system that indicates the direction that the controller is pointing. Sony's latest [prototype controller](#) for the PlayStation 3 has a glowing globe that is tracked by a USB camera, as well as embedded accelerometers.

Microsoft [recently announced](#) an ambitious controller development programme codenamed '[Project Natal](#)' for its Xbox console. Earlier this month delegates at the E3 conference saw it operating in a range of game applications, as well as supporting interaction with a computer avatar called Milo. (The latter is shown in a video embedded in this [BBC News report](#).) The system relies entirely on cameras to capture body movement and facial expressions - the user does not hold any hardware at all. Project Natal uses infrared detection, plus sophisticated processing algorithms, to track the precise position of the user's limbs, even in low light.

Microsoft has given little indication of the release date for Project Natal, which is thought to be at least a year away, or the hardware required to process movements detected into meaningful control signals. Nevertheless, even more than the introduction of multitouch, recognition of gestures in 3D will require a fast processor.

### **Interpreting gestures**

The ability to detect a wider range of gestures can actually lead to greater problems for an interface's designers, as it is necessary to understand the user's intention behind the gesture. The 'WIMP' (windows, icons, mice and pointers) interface uses a carefully restricted set of gestures which, once learned by the user, can easily be applied across a wide range of software. When more gestures are introduced, there is a danger that users become more readily confused about which one is required.

Microsoft researchers [recently published](#) a paper based on people's own selection of gestures for particular computer commands, finding strong agreement for some actions but great variability for others. Perhaps inevitably, among users that might already be expected to be familiar with the desktop paradigm, the paper said that 'desktop idioms strongly influence users' mental models'.

Aspects of gesture are cultural, so British people will tend to put a tick rather than a cross in a tick box, while signals, such as 'thumbs up', can have completely contrary implications internationally. This presents considerable difficulties to interface designers who want to integrate 'natural' body movements into applications aimed at a global audience.

The efficacy of gestures could be improved through feedback systems that tell the user that a particular action has been recognised. 'Virtual keyboards' on touch screen phones can be more difficult for users, as they cannot feel the edges of each key or sense that they have 'pressed' a particular button. Haptics (use of vibration and other mechanical feedback) may assist in this area.

### **Limitations**

Touch interfaces can lead to further problems: when is a touch intended (as against accidentally resting the heel of your hand on the surface)? Does the very 'pointing mechanism' (a finger on a mobile phone's screen or a teacher's arm in front of the IWB) obscure the image displayed to the user? A Microsoft researcher [has suggested](#) that a touchpad on the back of the device and a visual representation of that finger on the display could give more accurate hardware control on small screens.

Accessibility of touch screen devices is a big concern: without haptic feedback, it is very hard for someone with visual impairment to use such screens. TV Raman, a Google researcher, has developed a [dialling technique](#) and method for [looking up contacts](#) suited to visually impaired users. He points out that these approaches can benefit all users, as there are times when it is not convenient to look at the screen to see what to 'press'.



Physical disabilities, the age of a user or their mental capacity may also affect their ability to learn or enact particular gestures. Nevertheless, assistive technology that incorporates gesture recognition may be of great benefit, as arm movements can be much easier for someone with fine motor control difficulties and more intuitive to young children.

One issue that has received limited attention to date is the possibility of new forms of repetitive strain injury (RSI), which can come about through continually making similar movements or interacting with unyielding surfaces (like mobile phone screens that have no 'give' in them).

### **Opening up applications**

Gestures can be much more intuitive for users, especially where the system mirrors the actions to control an on-screen avatar, a robot or other 'remote' device. Although requiring sophisticated sensor arrays and fast processors, tracking a single user and interpreting their actions is simpler (in principle) than attempting to discern the intention of an unknown number of users collaborating on multitouch hardware. Although straightforward goals can be set that require multiple users to carry out the same actions until each objective is achieved, does this truly add to learning? Development of pedagogically meaningful activities, whether harnessing the power of multitouch interfaces for competition or collaboration, is really at an early stage but is an area to watch.

Immersive environments, such as Microsoft's Milo demonstration, are extremely attractive, but require a great deal of hardware to achieve results that (arguably) could as easily be achieved by other means. This is not to say that specific categories of user (such as autistic learners) will not benefit tremendously from this type of computer-mediated interaction, while users with disabilities may also find suitably designed gesture-based systems simpler to use than more traditional forms of input.

Educational innovators are working with the latest multitouch and 3D gesture detection systems to uncover their potential for education, but widespread adoption will depend on devices that are within reach of educational budgets and the development of suitable, educationally valid content. Integration with existing systems may also be an issue.

## **Multimedia news**

### **Microsoft introduces camera-based motion control**

Motion capture using cameras and sophisticated processing algorithms is not new, but Microsoft intends to bring it to the mass-market with '[Project Natal](#)' and a new controller for its Xbox 360 games platform. The two other major contenders in the games console market, Nintendo and Sony, have both made recent announcements (respectively) on expanding the [Wii controller family](#) and introducing a [new controller](#) that works in conjunction with the PlayStation Eye (Sony's PlayStation USB camera system). The latter has yet to be released, but (like the Wii-mote) largely relies on

the player holding a piece of hardware that contains accelerometers to detect the user's movements.

The Project Natal controller, according to the [Microsoft press release](#), combines 'an RGB camera, depth sensor, multi-array microphone and custom processor running proprietary software all in one device'. These are mounted in a bar, which the user places above or below the display used for the Xbox 360, and are used to detect the body's movement and for voice commands. To detect motion in 3D (and in poor lighting conditions), Project Natal uses an infrared projector and a CMOS sensor to measure the distance of objects, such that Microsoft videos show the system recognising and reacting appropriately to a kick or a swipe of the arm. The software uses the RGB camera for face recognition, so that individuals can take up where they left off on a particular game, or different team members can be differentiated in a team activity. Microsoft also claims that the system can detect emotions in facial expressions and tone of voice, using these to determine the response of an application, as can be seen in the Milo video embedded in this [BBC News report](#).

Project Natal may be a year or more from commercial release, but it will introduce a new breed of motion controlled games and applications - if the specific instances showcased by Microsoft can be implemented by a wide range of developers. [One reviewer](#) certainly felt confident that the hardware was capable of matching the claims. It is but a short step, as [TechRadar suggests](#), to see this new computer operating paradigm as central to Microsoft's strategy to put its technology at the heart of every aspect of life. Project Natal could also create new potential for young children, the elderly and people with disabilities to control computer applications.

### **NVIDIA mobile devices to play HD video**

NVIDIA's Tegra chip aims to compete against processors from Freescale, Intel, VIA and others in powering mobile internet devices (MIDs) and media players. Tegra-based MIDs will be smaller than netbooks, but are designed to play HD video, have 'always on' wireless connections (using 3G, Wi-Fi or WiMAX) and have longer battery life.

The NVIDIA [press release](#) announced 12 Tegra-based products, with more in development, and stated that such devices could play HD video for 10 hours or music for 25 hours between charges. The company refers to Tegra as a 'heterogeneous multiprocessor architecture', combining CPU, GPU and HD video processors that can be used independently or together, depending on the requirements of an application. Devices costing around \$199 (£125) [are expected](#) later this year. There are [press reports](#) that Tegra processors will be at the heart of Microsoft's upgraded Zune HD media player. NVIDIA also said that it is working with Adobe to optimise Flash to run on its GPUs to save power while delivering rich graphical environments and Flash-based video.

MIDs are expected to offer larger screens and more processing power than mobile phones, while being less expensive, easier to carry and more power efficient than netbooks. This combination could be attractive to education, funding more devices within a given budget and providing personal access for learners to mobile content.

However, it remains to be seen whether the MID format, which is being promoted by Intel, will achieve the level of adoption required to make these more than a niche product.

### **New projector system for mobile devices**

Researchers at the Fraunhofer Institute have developed a prototype projector, using an OLED display, that is just 2.5cm long and 1.8cm in diameter (1.0 by 0.7 inches). Organic light emitting diode (OLED) displays generate light when a voltage is applied across layers containing organic polymers, so they do not need a secondary light source. In contrast, standard LCD (liquid crystal) displays work by filtering light through a series of polarising and coloured filters, making them relatively thick and reducing brightness of the output.

The [researchers suggest](#) that the new design produces 35 to 65 times as much light (over a given area) as a normal LCD display. The current system only has a monochrome output - colour would halve that brightness - but this level of luminance would considerably reduce the power needed to project an image, making it feasible to power the system from the battery of a PDA or smartphone. The researchers have a number of issues to resolve, including producing plastic lenses (which are lighter and cheaper to manufacture), creating a full colour display and reducing the size to fit more readily into small mobile devices.

Pocket projectors from companies including Aiptek, Dell, Optoma and TI are just coming to market (as reported in [TechNews 01/09](#)). These are small, independently powered, external devices that can produce an acceptable picture up to about 125cm (50 inches) across the diagonal. However, users have the inconvenience of carrying a second device and must ensure they have appropriate cables to connect to the image source. Mini projectors could be useful for fieldwork or in small tutorial groups.

### **Display produces all the colours seen by the eye**

Japanese display manufacturer, Sharp, actually [claims that its display](#) produces 99 per cent of all real-world colours, such as found on the surface of objects, in paints and in dyes. The new technology achieves this using five 'primary' colours (including yellow and cyan) for each composite display pixel, instead of the standard three (red, green and blue). The company says that the liquid crystal screen will faithfully produce colours - such as an emerald-blue sea or the golden-yellow of a brass instrument - that other displays cannot readily generate. Sharp has developed new image processing circuitry to extract the five primary colours used by the monitor from standard graphical data. The company also suggests that the new display uses the backlight more efficiently, which reduces power consumption, without giving access to the data to substantiate this assertion.

Industrial designers often need to see the 'true' colour of a new product before prototypes are created or production runs authorised. Consumers would also be interested in more accurate representation of products they are considering purchasing and medics could produce better diagnoses through remote observation systems where colours were more accurately presented.

## Display embeds photodetector cells

Wearable displays are constrained by the weight and size of the screen, which may be embedded into special glasses. The size of the display in turn limits the quantity of information that can be conveyed to the user, unless there is a mechanism to pan the image or zoom in to a particular area. Since the design goals for wearable displays generally assume hands-free operation, this presents a significant problem.

[Fraunhofer Institute scientists](#) have developed an OLED display that integrates a network of photodetectors. The matrix of embedded sensors are intended to be used to capture eye movements, tracking the wearer's focus of attention in order to open menus or pan the displayed image. Organic light emitting diode (OLED) displays, which produce light when a voltage is applied across layers containing organic polymers, can be very thin, lightweight and power efficient, which would increase the comfort of a wearable system. The prototype hardware features a monochrome display that is about half an inch (1.25cm) square, with a very limited imaging ability, but they hope to have a fully capable system working by early 2011.

Wearable displays are already used in specialist applications, but could become widespread among engineers, pilots, medical personnel, the military and other users needing ready access to information. A system with embedded eye tracking could be adapted to the needs of people with severe physical disabilities.

## Tactile touch screen interface

Users can find touch screens hard to use as there is little or no tactile feedback when a displayed 'button' is pressed. Phones and other devices may produce a small vibration once a 'press' has been acknowledged, but this response cannot help a sight-impaired user feel the edge of the button or create the sensation of a physical 'click'. Where the touch screen is embedded in a larger object, such as the dashboard of a car, it is almost impossible to provide feedback through vibration.

Researchers at Carnegie Mellon University are [reported to be working](#) on a system that pumps air into a narrow gap behind a semitransparent latex membrane. This membrane sits on an acrylic plate that has shapes cut out of it, so removing air from a given location can produce a concave dimple, just as filling the area with air creates a convex bump. The visual element of the interface is projected onto the membrane, while 'touch' is sensed as light from an infrared source is scattered towards infrared cameras by the user's fingers.

The 'objects' produced on the surface of the display need not be circles, and the combination of a differently shaped underlying hole in the acrylic, compared to the area of the latex that is stuck down, can produce alternate shapes depending on whether a positive or negative air pressure is applied. Sensors within the system could note pressure changes created by the user's fingers, to provide a graduated response based on how hard the screen is pressed. The current design features quite large buttons and could not be incorporated into a mobile phone due to the size of compressor needed to control air pressure in the unit.

## E-book readers update

A number of companies are competing in the market to provide readers for e-books, including iRex, Sony and BeBook. E-books have the potential to store many hundreds of novels, periodicals, textbooks and other 'printed' media in a small, light-weight device that uses a low power screen to yield a battery life of several days. Some readers are equipped with Wi-Fi or 3G mobile connections to enable them to download new content or store information from blogs and other websites.

A new, larger version of Amazon's Kindle, which has been very influential in this area, [has been launched](#). The [Kindle DX](#) has a 9.7 inch (24.6cm) screen in a unit that is nearly the size of A4 paper and only 0.38 inches (1cm) thick. Amazon suggests that the 3.3GB of memory on the device could store up to 3,500 books from the selection of over 275,000 in its store, although native capability to read PDF documents creates access to a much greater range of documents, including user-generated content. Publications and documents can be downloaded via 3G (in the US), or emailed to a device-specific email address, or transferred using the built-in USB connector. The pre-order price is \$489 (approximately £325), with the first units expected to ship this summer, although no announcement has been made about availability in the UK.

Five US academic institutions have agreed to run trial programmes involving hundreds of students accessing text books and course content through the new Kindle DX.

Reporting from the Kindle DX launch event, [TechCrunch says that](#) e-books now account for an additional 35 per cent of sales for all the titles available through Amazon. This figure is calculated on the number of sales, rather than value, and approximates to a quarter of all sales of these titles.

The [Cool-ER](#) reader from Interead will soon be available in the UK, [according to press reports](#). Like Amazon's Kindle range, the Cool-ER uses a grey-scale electrophoretic display from [E Ink](#). The slim device has a six inch (15cm) screen, 1GB of memory (plus an SD Card slot for up to 4GB additional storage), displays PDF files and supports the ePub book format (previously known as Open e-Book or OEB). Interead claims to have over 750,000 titles in their online [CoolerBooks](#) store, which provides titles compatible with readers from other companies. The new device is expected to ship in the US for \$249 (approximately £165) at the end of May, compared with \$359 for Amazon's Kindle 2, which also has a 6 inch screen.

## New colour e-paper technology

E-book readers use low power displays that can be read in sunlight, making the hardware lighter and energy efficient. Most commercially available devices are based on electrophoretic displays from E Ink. These use minute charged black and white capsules, suspended in a viscous solution, manipulated using electrical fields to produce a grey-scale image.

Manufacturers are keen to develop colour displays that work well in sunlight, have good colour depth and resolution, and a low drain on the device's battery. Such

displays, if they can be updated fast enough to accommodate the user's reading speed, would be more attractive to publishers than monochrome alternatives. One approach to this problem would be to create sub-pixels, using filters to create the necessary colours, but this can lead to images looking either dull or 'washed out', especially when dominated by one of the display's 'native' colours. (An image that contained a lot of red would, effectively, have active pixels across about a quarter of the page.)

Philips Research is developing a new approach to creating coloured e-paper, also based on electrophoresis. Transparent electrodes are usually arranged across the surface and rear of the display, so that particles migrate in the vertical plane dependent on the charge applied. The new approach has the pixels aligned horizontally, with two colours of microcapsule in a transparent medium in each cell. When in a neutral state, the white reflector behind the display can be seen, while the microcapsules are hidden behind the electrodes. When a charge is applied, capsules are drawn out from one end of the cell (according to the polarity of the charge applied) to colour the pixel as required. Pairs of these cells would be stacked vertically, with yellow/cyan and magenta/black particles in each. According to a [report in Technology Review](#), Philips claims that this system would create a display that is three times brighter than existing colour e-paper technologies.

### **New approach to e-paper displays**

E-paper displays have a variety of applications, from public signage, through updateable display advertising, to e-book readers. The requirements for such displays include reasonably quick image updates, the ability to retain the image without constant refreshing and the use minimal power. For example, most e-book readers are based on E Ink's electrophoretic system, in which minute charged black and white capsules are suspended in a viscous solution and manipulated using electrical fields to produce an image. Although effective, a major drawback is that the system is monochrome. Alternative colour displays have been produced, but they cannot be updated fast enough to provide an acceptable experience for the user.

[Researchers](#) from the University of California Riverside and other institutions have developed a new 'pigment' that changes colour as a magnetic field is flipped. 'Magnetochromatic microspheres' containing photonic crystals are dispersed in solution and printed on a surface. When the magnetic field is reversed, magnetic iron oxide nano-structures within the spheres are rotated, changing the colour that is produced. The microspheres create colours through constructive interference patterns in the reflected light rather than normal reflective pigmentation. Although the colour can be rapidly flipped, no indication is given about how displays based on this technology would be protected from external magnetic fields. The researchers make clear that much further work will be required to create a working system.

### **The digitally connected Post-It note**

A [Wayve](#) is a combination of a chunky wireless digital photo frame, a camera and an electronic Post-It note. Photos can be captured using the device's own camera, or pictures drawn on screen, and then annotated and sent to other Wayves, mobile phones and PCs. The touchscreen operates using a stylus or a finger and

embedded software drives a virtual keyboard, handwriting recognition, photo editing, connectivity and other functions. The website does not (at the time of writing) give detailed specifications, but the device (which appears to be about the size of a sheet of A5 paper) must include a 3G connection for messaging services, although there is no indication as to whether Wi-Fi is also available. A Microsoft [video](#) is available.

These devices, expected to be launched in the next few months, are really designed to be sold in pairs or higher multiples. Proposed pricing is given as £150 for a single device or £99 each for a pair. Further revenue will come from messaging, provided on a 'pay as you go' or contract basis. The proposed £9 per month contract would provide free communications between Wayves and to email, 100 texts and 25 messages. There could be a range of interesting educational possibilities, such as linking partner schools or for sending messages back from field trips and visits.

Wayve was originally a Microsoft Research project (at the Cambridge labs), which is being commercialised through [The Technology Partnership](#) (TTP).

## Hardware

### Analysis: Instant-on hardware

#### At a glance

- Users, including learners, like rapid access to information, especially when they are on the move.
- 'Always-on' systems are expensive on battery life, especially for larger mobile devices and desktop computers.
- 'Sleep' modes preserve data but use either significant amounts of power or take time to invoke.
- 'Instant-on' hardware should allow users to connect to the internet or perform other tasks within seconds of starting a device.
- New, fast, non-volatile memory technologies could be used both as working memory and longer term storage, allowing for faster system recovery from sleep.
- Until such technologies have been commercialised, dual-boot systems that offer a 'lightweight' operating system can provide something more akin to an instant-on experience.

#### Always on, always connected

Many people like to have their email and social networking information at their fingertips and demand is growing in businesses that employees will always be available. These trends have reinforced a development cycle of devices with greater connectivity and faster access, linked to consumer expectations that seem always to be one step ahead of the hardware.

Learners moving between classrooms could benefit from instantly available mobile computing resources, as they would not need to log on to desktop PCs or wait while their own device was ready before accessing learning materials.

Two main solutions to having access immediately to hand would be to leave the hardware constantly switched on (which drains battery power) or to find some method by which they can 'come to life' almost instantly. Mobile phones take the 'always-on' route, but this is less sustainable for larger devices with power-hungry screens, so developers are looking to alternative 'instant-on' solutions.

### **Sleep states**

Operating systems offer a range of power-saving strategies, from hardware timeouts for devices (like screens) that take most energy, to hibernation states. Advanced configuration and power interface (ACPI) compliant motherboards (used by most PCs) offer two commonly used sleep modes: standby and hibernation.

Standby, which may also be called 'sleep' or 'suspend', is defined by ACPI's 'S3' mode, in which power is provided to the RAM in order to maintain working data, but all devices (as far as possible) are switched off. In this state, computers can rapidly become operational but data in memory is vulnerable to total power failure, so some operating systems support a 'hybrid' standby mode that also writes data to disk.

Computers in hibernation (S4) write all information from memory to disk. Although this is slower than leaving data in memory, it gives greater security to the user, uses far less power than standby and should return the system to a usable state much faster than powering up after the machine has been shut down completely.

(Hibernation can still consume some power, as computers retain, say, an active connection to the Ethernet card to allow the machine to be 'woken' remotely.) Hibernation is the most power efficient of the two sleep modes, but can introduce a lengthy delay - as users may see it - before the machine is ready to operate.

### **The BIOS legacy**

Switching a computer on invokes a bootstrap routine that is stored in non-volatile memory, such as EEPROM (electrically erasable programmable ROM) or 'flash' memory. The bootstrap sequentially loads the device drivers required for basic hardware functions, readying the hardware to load the main operating system. Key parts of the bootstrap routine are incorporated in the basic input output system (BIOS) of modern PCs, which performs a variety of low level tasks and stores important system information, such as the location of the operating system.

The BIOS of Intel x86 hardware is limited to the more compatible, but less efficient, 16-bit instructions. This has driven the development of customised BIOS extensions that address more memory or control specific devices. Recently, the extensible firmware interface (EFI) used for Intel Itanium processors, has been redeveloped and refined for use on other systems. It is now known as Unified EFI (UEFI), with motherboards based on the latest specification recently emerging in the market. (See [TechNews 01/09](#).) UEFI allows programmers to write boot-time applications that can be processed without loading the whole operating system, making it much quicker to load a simple internet browser or email client.

Some manufacturers have developed systems that allow dual-booting, so the user can intervene and choose to load a 'lightweight' Linux kernel rather than (for



example) the full Windows Vista operating system. Among these are [Presto](#) from Xandros, [HyperSpace](#) from Phoenix and [Splashtop](#) from DeviceVM, with Acer, Asus, HP, LG and Lenovo among the companies installing such systems on selected models during manufacture.

Each system has its own advantages, relating to speed of booting or application processing, battery usage and support for specific hardware or applications. Some systems require installation of code within the BIOS, but Presto claims that it can be installed purely at a software level. HyperSpace comes in two versions, one as a 'Dual' boot and the other a 'Hybrid' that uses Intel's Virtualisation Technology to run the software in parallel with a full operating system, allowing the user to 'hot swap' between the two. HyperSpace is licensed on an annual basis, whereas a single Presto licence key costs just \$19.95 (about £12.50) to fully activate the trial version.

Manufacturers are also looking at supplying additional, low-power processors to run the instant-on operating systems. For example, Dell's [Latitude ON](#) technology, used in some of its laptop models, utilises 'a dedicated low-voltage subprocessor and mini-OS', which can synchronise data with Microsoft Exchange in addition to carrying out other tasks.

### **Application availability**

The main aim of instant-on systems is to have access to email, calendar, internet and other applications. However, this assumes that a network connection - generally wireless - is available, and that the software is capable of accessing the required data. Mozilla's Firefox browser runs on Linux and provides support for most web applications, so this should not be a problem, but business-oriented tools like Microsoft Exchange may not be so readily accessed. Due to developers seeking to keep costs down, as well as flexibility of the open source model, applications such as Open Office may be provided for word processing and other 'productivity' tasks, but users need to ensure that the file formats chosen are compatible with users elsewhere. The instant-on software may only provide basic drivers, if at all, for graphics cards, DVD players and other hardware, severely limiting tasks like video playback.

A significant problem can be accessing files created within the main operating system. Windows Vista has its own file management technology (NTFS), which may leave files or disk partitions inaccessible to the instant-on software, especially where strict user security policies have been enforced. USB flash drives may help overcome this, so long as the hardware is supported in both systems.

Dual-booting to online resources can also open up computers to security threats, such as trojans, viruses and spyware. Anti-malware applications normally run within the main operating system, so the PC can be quite vulnerable, with greater potential low level access to the hardware.

### **Changing memories**

Ideally, instant-on systems will retain working memory without any power drain and will be accessible as soon as the system is reactivated. Flash memory provides part

of the answer, as it is much quicker than a normal hard drive, but it cannot directly preserve the active state of the processor. Other types of memory that could overcome this restriction are coming closer to practical implementation, although a great deal of work remains to be done.

FeRAM (see [TechNews 03/09](#)) can store data much faster than flash memory. It uses a ferroelectric layer, which has an electric polarisation that can be reversed by applying an external electrical field, allowing it to store information indefinitely until a new field is applied. Magnetoresistive RAM (MRAM), using magnetic fields rather than electrical polarisation, is somewhat similar in principle to FeRAM, while spintronic devices use the orientation of the so-called 'spin' of electrons to store data. Since these technologies work far faster than flash, they can be used both as working memory and long-term storage, obviating requirements for fast cache memory or additional forms of non-volatile storage. If the electricity supply were to be cut, the working state of all memory operations would be stored and could be immediately recalled as soon as power was restored.

A more recent area of theoretical development, memristors, has recently been demonstrated in the laboratory. (See [TechNews 03/09](#).) Memristors could potentially store both the contents of memory and the logical operations being performed, so preserving a complete 'snapshot' of a system that could be restored on demand.

### **Always on, and on**

Users have become accustomed to ready access to data through mobile devices, such as phones and netbooks, many of which are designed to be always-on. This approach often relies on web services to store the data, making it available to the user's other devices, as well as acting as a backup. However, always-on devices need good batteries, or other power sources (such as solar or energy from movement), to keep them active. At some point, even smartphones must be booted, perhaps through power failure or software crashes, enforcing a wait on the user. Being able to completely switch off a device and immediately restore it to full operation would be very attractive to users (except where they are using 'push' services that need continued connectivity.)

Booting existing devices, even with fast processors and storage, seems to take longer with each new generation of hardware and operating system, due to the increased overheads required to support features like 3G radios or HD video, as well as loading software to protect system security. Dual boot systems are a useful strategy - often increasing effective battery life - but compromises must be made about the facilities offered within the 'instant-on' environment. However, true instant-on devices will not become available until new non-volatile memory technologies, that work as fast as normal RAM, can be commercialised.

## **Hardware news**

### **Ferroelectric materials to allow instant-on booting**

Researchers have been seeking to construct memory components that have the flexibility of RAM but the permanent storage of ROM. Flash memory holds electrical

charges in discrete 'cells', which persist without needing to be refreshed, but it has relative long response times, making it unsuited to caching information during processing. This makes flash memory less suited to preserving the state of the computer when it is switched off, unless data is specifically written to flash as part of the power-down process. Flash memory used in this way is relatively slow and creates a significant drain on the battery, which can be ill-afforded in mobile devices.

[FeRAM](#) and [memristors](#) have both been proposed as components in the solution to this problem. In FeRAM, the normal dielectric (insulating) layer in the semiconductor stack for a storage capacitor is replaced by a ferroelectric layer, which has the property of electrical polarisation that can be reversed by applying an external electrical field. Flipping the polarity to store a 0 or 1 bit can be achieved more rapidly than charging a capacitor in normal memory.

[Researchers](#) from three US universities and partner organisations have produced a new method for placing strontium titanate, a ferroelectric material, onto silicon, while omitting the intervening layers previously used. Based on a theoretical prediction, the team managed to deposit an extremely thin layer of strontium titanate on the silicon, while also reducing the spacing between the atoms in the material. This 'compression' causes the strontium titanate to become ferroelectric, creating the possibility of building hybrid transistors that directly incorporate ferroelectric storage.

'Sleep' states in computing hardware drain the battery, since RAM components need to be continuously refreshed, but power could be cut (even accidentally) to a hybrid transistor and it would be able to resume from the same point as soon as the power was restored. Such hardware could allow learners to close the lid on a laptop before a break and resume work with no delay after, having consumed no power in the intervening period. The lead researcher [could not predict](#) when such a transistor might be produced, but saw great potential in such devices.

### **Flexible memristors developed**

Memristors are a fourth fundamental circuit, able to 'store' a variable level of resistance that depends on the voltage level that has previously been applied to it. Memristors (covered in [TechNews 03/09](#)) could be used to act as both processors and as non-volatile memory, maintaining the state of a system even after the power has been switched off.

[US engineers](#) at the National Institute of Standards and Technology (NIST) have developed a flexible circuit that demonstrates the properties of a memristor. Using a relatively inexpensive process, a thin layer of titanium dioxide is deposited on a flexible polymer sheet, to which electrical contacts are attached, forming a flexible memory switch that can be controlled using less than 10 volts.

In a [separate development](#), Stanford chemical engineers have developed a way to deposit single-walled carbon nanotubes in a predictable pattern on flexible, semiconducting substrates. Such nanotubes, which consist of a very fine tubular network of carbon atoms, conduct electricity and are pliable, promising very lightweight flexible electronics.

Flexible electronics would be more robust, as they are much less likely to break when a gadget is dropped, and could be used to control displays fixed to curved surfaces or as sensor arrays attached to a person's skin. Both teams need to do further work on the properties of their discoveries, so specific applications are some way off.

### Mobile computing platforms update

[Freescale](#), [Qualcomm](#) and others are developing ARM processor-based chipsets for devices that are being [termed 'smartbooks'](#). These devices resemble netbooks outwardly, with small screens (around the 10 inch, 25cm mark) and normal keyboards (or tablet designs), but they are optimised to be much more power efficient and are expected to cost around \$199 (£125). These devices will be 'instant-on', with permanent wireless (or mobile) connection, allowing 'push' email systems to put messages on the machine without the user needing to check for mail.

Sun has been working to optimise the Java SE web programming language for Qualcomm's Snapdragon processors. [According to Sun](#), the collaboration has increased Java performance on ARM-based processor platforms by 32 times.

It [has been reported](#) that Microsoft will not be producing a desktop version of Windows to run on smartbooks, as the code would need to be re-written for ARM's architecture. (Intel's x86 processor microcode, also used by AMD, is different to ARM's RISC chip designs. Reduced instruction set computing aims to use fewer codes, while further optimising frequently used instructions at the hardware level.) Open source operating systems, especially Linux and Google's Android platform, are seen as two of the main candidates for use on these devices, although Microsoft has versions of Windows Mobile and Windows Embedded Compact that work on ARM-based processors. [Other reports](#) say that NVIDIA has made Windows Embedded Compact its 'platform of choice' for netbooks based on its new Tegra chip

Microsoft is [reported to be pleased](#) with the progress of what it has termed 'consumer internet devices' (CIDs). CID hardware covers a broad group of systems that use embedded internet connections, subsuming Intel's mobile internet devices (MID) category, plus small web tablets, MP3 players, digital photo frames, e-books, internet connected televisions and even home appliances. These devices will run the x86 versions of Microsoft's Windows Embedded operating system, which the same report states will be based on Windows 7 from October. There are many alternative embedded operating systems, including a number of versions of Linux.

Both [Intel](#) and [AMD](#) recently announced processors and chipsets for 'ultra-thin' notebook PCs. Intel stressed its 'ultra-low voltage' (ULV) range, designed to extend battery life and to be capable (along with the appropriate GS40 Express chipset) of HD video playback. Some commentators have termed these chips CULV (consumer ULV). AMD's new dual-core range is based on the Neo processor first announced in January ([TechNews 01/09](#)), which it is combining with an integrated ATI Radeon X1250 graphics processor in its latest 'Yukon' chipsets. [According to reports](#), AMD want to position ultra-thin notebooks between netbooks (which have more limited

graphics capability) and more expensive ultra-portable laptops. The Intel chips, designed on a 45nm process, should be more power efficient and cooler than comparable 65nm AMD designs, due to shorter distances between processor components.

### **128 gigaflop processor**

Fujitsu's new SPARC64 VIIIfx 'Venus' processor [is reported](#) to be able to process instructions at 128 gigaflops. (That is 128 billion floating point operations per second.) This speed is said to be 2.5 times faster than Intel's high performing, dual core Itanium 2 chips, while the report continues with Fujitsu's claim that Venus takes a third of the power (35W) of the Intel chips. The Venus processor has eight 64-bit cores, which are manufactured using a 45nm process. Although Itanium 2 processors are based on older, more power-hungry 90nm technology, [Intel plans](#) to manufacture faster 65nm 'Tukwila' versions early next year and 32nm 'Poulson' processors thereafter.

The 64-bit Venus processor is designed for use in powerful servers and supercomputers, but has not been given a launch date. Other manufacturers, including NVIDIA and AMD, are producing [faster 'GPGPU' processors](#), for use in graphics and specialised mathematical modelling applications, but these cannot be directly compared to a CPU.

### **New energy ratings for monitors and servers**

The Energy Star rating system was initiated in 1992 to recognise the power efficiency of electronics products supplied to the US Government, although it is now deployed much more widely. [The latest \(version 5\) standard](#) for monitors and other displays governs power consumption when on, while in a 'sleep' mode and while 'off' but plugged into a live socket. [PC Advisor reports](#) that the number of existing displays that would qualify for the updated standard would fall from 45 to under 25 per cent. The new standard also applies to digital picture frames and large commercial displays measuring up to 60 inches (approximately 1.5m). Specifications for displays under 30 inches apply from 30th October this year, while other devices will be covered from January next year.

The US Environmental Protection Agency (EPA) [estimates that \\$1 billion](#) (about £660 million) could be saved in the States alone if all displays conformed to the standard, with most of the savings coming from large display devices. Educational institutions would equally benefit from the average 20 per cent power savings that would be made by selecting 'qualified' devices compared to 'conventional' ones. Most manufacturers and many suppliers label Energy Star devices, or include reference in specifications, allowing buyers to use compliance as a criterion in selection.

Data centres consume large amounts of power and servers (unlike terminals) are rarely switched off, even on small networks. ('Green data centres' were covered in [TechNews 01/09](#).) The EPA also [recently announced](#) a new standard for servers, which it suggests could eventually save \$800 million (£500 million) per annum in the States.

The [new standard](#) is particularly aimed at enterprise servers and covers issues including:

- the efficiency of the power supply, such that the level of waste heat is minimised
- access to power consumption and other performance metrics for monitoring and control systems
- availability of power management systems that can optimise power use across a range of operating states
- standardised power and performance data sheets, making it easier for purchasers to compare products.

Local authorities, broadband consortia and large education establishments may have data centres containing equipment covered by the new standard, but it is likely that the requirements will be updated for other server equipment in future and that manufacturers will employ similar technology in lower specification servers.

### **New storage strategy - information dispersal**

Fault-tolerant data storage is generally achieved through replication across devices and (preferably) locations - if one device fails, the same data should be available on another. This is the principle behind RAID - the redundant array of inexpensive (or independent) disks, where data is replicated between disks in the same unit. Although effective - if data is replicated at different locations to reduce damage occurring through events like fire and flood - this strategy is inefficient and potentially insecure: data has to be transmitted and replicated at several locations, and each location will hold all or part of the data in intelligible form.

A dispersed storage network (dsNet) appears superficially similar, but relies on complex algorithms to divide data into unrecognisable 'slices' - data appears in more than one slice, but each slice is unique and (in itself) almost meaningless. This means that stealing disks or snooping on data transmissions will reveal little which is intelligible, unless a significant proportion of data is captured. Depending on the level of risk and degree of protection desired, a threshold is set by the system manager that determines the number of locations where data must be held and, consequently, the number of transmissions required to store a given amount of data. So long as a minimum number of systems remain intact, the data can always be reconstructed from the remaining storage, while automated systems can run in the background for 'self healing' of any data errors.

[Cleversafe](#) is one of the companies seeking to commercialise dispersed storage networks based on these principles, although the basic technology is open source. Cleversafe can install specialist storage and processing hardware on site, or (in the near future) will offer a version that operates across the internet to hosted data stores. Cleversafe suggests [a considerable reduction](#) in the amount of storage required to protect data against a predicted number of simultaneous failures, compared to purely copy-based systems and those that use parity algorithms to protect data integrity. (If at most 4 devices out of 16 were to fail, then 1TB of data

could be stored in slices that total only 1.45TB across dispersed storage network, whereas this level of protection would require five separate 1TB stores for a copy-based system. A parity-based system that used four storage devices to provide a similar level of protection would require around 1.45TB total storage, but could only tolerate the loss of one device, according to Cleversafe.)

Writing in [TechNewsWorld](#), Chris Gladwin, the CEO of Cleversafe, points out that dispersed storage could also reduce costs for content delivery networks (CDNs), as a stream of video data could be drawn from any subset of the storage locations (above the minimum threshold) to balance the load across the system.

### **Storing data in five 'dimensions'**

Researchers from the Centre for Micro-Photonics in Australia [have developed](#) a new way to massively increase the amount of data held on optical disks - CDs store around 740MB and single-layer, single-sided DVDs 4.7GB, but the new technology could provide up to 12TB on the same size of disk. (A terabyte is approximately 1000GB.)

Standard CDs work on the basis of measuring laser light reflected from 'pits' formed from indents in a foil layer embedded in the disk to encode the disk's data. Dual layer DVDs use a semi-transparent encoding surface for the first layer, allowing a second layer to be used for data storage. The new system can produce as many as ten layers, with other properties (polarisation and wavelength of the light) adding another two 'dimensions'.

The researchers used gold nanorods to encode data - a sufficiently powerful laser pulse melts the nanorod and changes its shape. The dimensions of the nanorods, which are randomly dispersed throughout the disk, govern the wavelength of light they respond to, while the polarisation of the incident light compared to the nanorod's orientation affects how it absorbs that light. The reading system is based on a 'blue-shift' in the emitted light, caused by the nanorods absorbing photons and releasing fewer at higher energy levels when a nanorod is illuminated by a laser pulse. The system [is reported](#) to be able to write at speeds of 1Gbit per second, although re-writing is not thought possible.

The new encoding method requires laser light sources for each of the three colours and the [experimental setup](#) involved a bulky photomultiplier in its detection system, rather than more practical photodiodes that would be required for a consumer product. Lower density holographic storage systems (reported in [TechNews 11/08](#)) are much closer to commercialisation, with some products possibly appearing later this year.

### **5Gbps ExpressCard**

ExpressCards, which have replaced PCMCIA cards and PC Cards, are designed to expand the capabilities of PCs - they can add flash memory, mobile and upgraded wireless connectivity, television tuners, card readers and many other capabilities for mobile devices running Linux, Mac and Windows operating systems. Other connectivity options, like USB and FireWire, have taken parts of this market in recent

years, but the standard still has active support, with the PCMCIA trade association stating that 95 per cent of consumer laptops have slots based on the current or older standards.

A new ExpressCard v2.0 standard [has been launched](#) that can provide data transfers at rates up to 5Gbps, depending on the protocol and hardware associated with a particular application. These speeds would allow for the addition of a USB 3.0 connection (which can operate at up to 4.8Gbps), an external hard disk using the eSATA serial connection standard, or high speed video and streaming media adaptors. The new standard is backwardly compatible with previous versions of ExpressCard, with new products expected to appear early next year.

### **New SATA data transfer protocol ratified**

Serial ATA (SATA) interfaces are used in most modern PCs to connect hard disks and solid state drives (SSDs). The Serial ATA International Organization (SATA-IO) [released at the end of May](#) its latest Revision 3 specification for such interfaces, which defines hardware and protocols that can operate at up to 6Gbps. The lower speed (3Gbps) of the previous definition is beyond the transfer rates of most consumer hard drives, but SSDs have the potential for much faster operation, as they have no moving parts. For example, some of [Intel's latest SSDs](#) can read sequential data at up to 250MB per second, which would be 2Gbps plus overheads. The new standard supports enhanced queue management to improve transfer rates, especially for multimedia applications, and new connectors for smaller form-factor hard disks and optical drives.

Devices based on the new standard, which is backward compatible, [are expected](#) to appear early next year. New motherboards will be needed to take advantage of the full 6Gbps data rates. The new standard will benefit high-end PCs and some servers that use SSDs, especially when streaming multimedia files.

### **Free wireless power to power gadgets**

The environment is constantly bathed in radio waves, each of which consists of a tiny amount of energy. Nokia [is said to be](#) developing a gadget charger that harvests this energy to power wireless devices. The current system can generate 3 to 5 milliwatts of power, which is inadequate to power most mobile devices. The Cambridge-based team aims eventually to produce 50mw in areas with strong radio signals, which would provide sufficient to trickle-charge a battery while the hardware was operating. The antenna would need to operate across a wide range of frequencies to harvest that amount of power, so they are looking to capture energy from signals between 500MHz and 10GHz. The lead researcher is quoted as looking at three to four years before a viable system is integrated in products, but [Nokia has denied](#) the existence of an actual working prototype.

RFID tags use similar energy-harvesting technology to produce sufficient power to run their embedded transmitters, but they only need very small amounts of energy to broadcast a short-range signal. A number of sensor systems can also capture energy from localised radio signals, but they are also extremely low-power devices compared to personal media players and other devices.



## Software and internet

### Analysis: QR Codes and other 2D barcodes

#### At a glance

- Machine-readable barcodes can transmit information far more quickly and accurately than human input.
- Two dimensional barcodes are replacing older, linear 'strip' codes, as they can store much greater amounts of information.
- A variety of 2D barcode formats is available, some of which are proprietary and others are governed by published open standards.
- 2D barcodes are processed using image recognition applications installed on mobile phones or associated with more specialised hardware.
- Educationalists have tended to focus on the QR Code format, with innovative examples being published by the University of Bath and on blogs.
- 2D barcodes face a range of barriers to adoption and could be seen as an interim solution before RFID tags become widely used by consumers.

#### The changing face of barcodes

We are familiar seeing barcode strips in many contexts, especially on consumer goods that use the European Article Number (EAN) system, which is now governed by the [GS1](#) supply chain standards group. These barcodes are linear, in that a reader detects the pattern and (effectively) sweeps across it in the horizontal direction. Tagging systems, including barcodes, are used in many applications, such as identifying boarding passes, numbering concert tickets, uniquely identifying industrial and military goods, tracking items in transit and marking postal items with machine-readable addresses. It is frequently suggested that machine reading considerably reduces error rates, from (typically) 1 in 300 for human input to (at worst) 1 in 15,000 for barcodes.

Barcodes are quite limited in the amount of data they can store compared to the space they take up on the item - a standard EAN-13 barcode codes just 13 digits. Many alternatives have been proposed that allow for more data to be stored, such as the item's origin, a description or a web link.

#### 2D barcodes

'Stacked' barcodes provide an improved solution, with multiple, uni-directional passes across the code from different starting points, each of which reads new data. PDF417 ([see Wikipedia](#)) is one of the more common examples of this system.

Recently, two dimensional barcodes, which cannot be read by scanning in a single direction but must be processed as a complete image, have become widespread. These use a series of 'modules' (normally black-white spots representing binary information) laid out on a grid, often printed as a square or rectangular matrix. This matrix contains 'finder' elements, so the image recognition system can locate and orient the pattern, and 'timing' information to ensure that the correct grid-spacing is identified.

There are many types of barcode - some of which are illustrated in this [Wikipedia article](#) - but the most common 2D types include:

- **QR Codes.** These 'quick response' patterns were invented in Japan in 1994 and patented by [Denso Wave](#). However, the coding system has been standardised as ISO/IEC 18004:2006 and the company has promised not to assert its patents. QR codes use a square grid with 21 to 177 modules along each axis. At the lowest level of error correction, a QR code can store up to 4,296 alphanumeric characters. [One review](#) suggests that QR Codes can be slightly faster to detect and decode.
- **Data Matrix.** These codes were invented in 1989 and are generally square, with grid sizes from 10 to 144 units on each side. The coding system is also open source, currently defined by the ISO/IEC 16022:2006 standard, but it has been widely implemented by [Semacode](#). Depending on how data is encoded, up to 2,335 alphanumeric characters can be stored in single symbol. It is claimed that Data Matrix stores more information (for a given array size) compared to other 2D barcodes, as demonstrated in [this illustration](#).
- **Aztec code.** This [public domain coding system](#) (originally created by Honeywell) can store up to 3,067 alphanumeric characters using grids from 15 to 151 units square.
- **High Capacity Colour Barcode (HCCB).** This proprietary format is being marketed as [Microsoft Tag](#). The company says that the format will be free for the duration of the beta (trial) period, but that it reserves the right to charge thereafter. HCCBs use a 5 by 10 grid of coloured triangles (storing 105 bits in the 4-colour version) that code for a URL. To extract information, an HCCB reader must decode the data and look up the associated address via a Microsoft server, which will then redirect the user to the required web page. Although a web connection is always required, due to this lookup process HCCBs can 'expire' or be updated to a new URL.
- **Shotcode.** [These are circular](#), represent 40 data bits and must lookup the underlying URL in a similar way to HCCBs.

Each format has restrictions on how it can be used, such as: requirements for a blank 'quiet' zone around symbols, restrictions on the size of each 'dot', methods for identifying the data types present, rules regarding combining multiple code blocks and selectable levels of error correction, depending on the format chosen. Both QR Code and Data Matrix can (for a given symbol) be printed at a wide range of sizes, from etching on small components to poster display on the side of a building.

2D barcodes must be read with applications that perform image capture, recognition, orientation and decoding. The hardware may consist of specialist scanners, web cams or camera phones, along with appropriate software. Barcodes can contain URLs, phone numbers, plain text, text messages, map locations or contact details, which may be handled more effectively by some applications than others.

Barcodes are considerably more accurate at transmitting data compared with users having to type it in. More data can be quickly provided to the user, using little space on screen or in a document, and (using a phone's picture storage) kept for later reference. Online converters (such as the one from [Bath University](#)), browser extensions and custom interfaces (such as those based on [Google's chart APIs](#)) can be used to generate codes.

### **Educational uses**

Educational developments have tended to focus on QR Codes, which are widely used in Japan (due to native support for Kanji characters) and, therefore, supported by many models of mobile phone. JISC has funded a [project at the University of Bath](#), while other innovators are experimenting with possible uses and blogging their results - [Andy Ramsden](#) writes on QR codes and [Inge de Waard](#) has a range of posts on the topic. Available briefing papers include [7 things you should know about QR Codes](#) (EDUCAUSE Learning Initiative) and [The use of QR codes in Education: A getting started guide for academics](#) (by Andy Ramsden of Bath University).

The following examples give a flavour of the range of suggested uses, drawn from educational blogs:

- Tagging locations with descriptions or [personal histories](#), as places in a [revision 'treasure hunt'](#) and for [orienteering](#)
- 'Scavenger hunt' activities for induction days, at galleries, or in exhibitions
- Labelling and quick reference, for example resources in a [library catalogue](#), [equipment in a laboratory](#) or plants in a botanical garden
- Providing online follow-up information and activities from presentations, or links to homework at the end of a lesson
- Anonymous labelling and tracking, for example [coursework](#)
- Creating multiple choice responses for quizzes and [formative feedback](#), which then lead to an online form for longer responses
- Registering students or helping users with disabilities identify themselves to computer systems.

### **Barriers to adoption**

2D barcodes may be beneficial for some educational purposes, but a number of questions should be considered:

- Are camera phones (and other reader hardware) sufficiently available to learners and staff?
- Do institutional policies permit learners to carry and use phones in this way?
- Are reader applications available for the phones that learners use and can they process the required content? (For example, some applications can decode an SMS message request but then fail to launch the messaging application to send the text.)
- Do the proposed uses require a data connection from the phone?
- Who will pay the mobile phone charges?
- Are web sites referenced sufficiently readable on mobile devices?

- Do the intended uses cause accessibility problems? Can users easily locate the code on screen or paper and can they read output on the device?

## Future

Recognition of 2D barcodes is likely to be growing as they become more widespread, for example on promotional [Pepsi packs](#) and providing nutritional information on [McDonalds meals](#), but knowledge of their purpose and how to read them remains sparse. Many formats, each of which has advantages in given contexts, are competing in this space, although protected standards have not been published for all of them.

2D barcodes could be seen as an intermediate, optical technology, which will be overtaken by electronic tagging systems like RFID. (Radio frequency identification tags are already used in many applications, as noted in this [recent report](#).) However, barcodes are generally based on publicly available formats, can be easily generated and are simple to use in a broad range of contexts.

QR Codes may find more than niche uses in education, but it is too early to predict the extent of their adoption. Results from the Bath project will be written up as case studies over the next year or so, while interim results and other uses will emerge through educational blogs.

## Software and internet news

### WolframAlpha - the 'computational knowledge engine'

[Wolfram|Alpha](#) would prefer to be known as a 'computational knowledge engine' rather than as a competitor to Google, Microsoft's Live Search, Yahoo or any other search system. Instead, it has its own 'internal knowledge base', which has been developed over several years, consisting of a library of factual information drawn from the web and other sources, algorithms, search methods and models. Because it derives each answer from data that has been vetted through its own curatorial pipeline of researchers, the website states that Wolfram|Alpha should be quoted as a 'primary source' in academic and educational research.

Wolfram|Alpha deals in factual questions, such as mathematical solutions, statistics, conversions, historical information, financial data, distances and more. The current knowledge base consists of more than 10,000 billion pieces of data that are manipulated using the Mathematica 'symbolic computation' language. The process is mediated by a linguistic processing system that attempts to turn search queries into a form that Wolfram|Alpha understands and outputs as a solution in tabulated format. [According to CNET.com](#), a substantial portion of the processing power behind Wolfram|Alpha derives from a supercomputer rated sixty-sixth in the world, built by Dell using 4,608 Intel Xeon processor cores and more than 65TB of memory. (1TB is approximately 1,000GB.)

Data is not linked to specific websites, although brief 'source information' is listed beneath the search results and alternatives resources (such as Wikipedia) are suggested in a box to the right. This makes fact checking quite difficult, as the

provenance of a particular source (or set of sources) for a specific fact cannot be assessed directly. However, a large number of accredited academics have been involved in different aspects of the project.

A quick review of reports from technology news services will indicate both the level of interest that Wolfram|Alpha has engendered and a variety of judgments on the degree of success the system has delivered in meeting its stated aims. Users have found the input processing system somewhat sensitive to the wording of searches and that some of the data has a US bias. Nevertheless, the developers aim 'to dramatically expand all aspects of Wolfram|Alpha, broadening and deepening our data, our computation, our linguistics, [and] our presentation'.

### **Microsoft revamps search**

Microsoft has joined [Google](#) by updating its current search offering. The new Microsoft service, which replaces Windows Live Search, is called [Bing](#). The [official announcement](#) refers to Bing as a 'decision engine', with a particular focus on helping when people are 'making a purchase decision, planning a trip, researching a health condition or finding a local business'.

A brief preview is available against the actual search results when the user hovers to the right of the list of links. Searching for an electronics item (with the location set to United States) may bring in a list of refinements on the left of the page, above the standard list of related searches, such as 'shopping', 'images', 'manual' and 'support'. The [Bing Travel](#) service allows users to search for flights and compare hotels, in a similar way to many other travel sites, such as Expedia, Lastminute.com and Opodo. Video results in Bing play an immediate preview when the mouse cursor is moved over the thumbnails, which could be used by students trying to circumvent filtering systems.

Microsoft quotes comScore statistics to suggest that 30 per cent of searches are abandoned and two thirds of the rest have to be refined due to the user failing to find the information required. In addition to using a variety of search engines, success in search would be improved by users having better knowledge of effective search techniques.

[Bing](#) is considered a 'beta' (trial) service in the UK, with some of the features limited or absent. Localisation will require appropriate algorithms and agreements with information providers. In addition to Bing and Google, search services are available from companies like AOL, Ask and Yahoo, and new services have been launched recently, such as [Wolfram|Alpha](#). One developer has created an experimental site, called [Bingle](#), that puts results from Bing and Google side by side.

### **New Google tools**

[TN0907, News, Software, Internet, Search]

Search engines continue to innovate in terms of presentation and features, with providers such as Microsoft and Yahoo seeking to differentiate their search by layout and relevance of results. Google, which remains the most popular search engine in the UK, has recently added a range of new features and services, including:

- [Similar images](#) is a Google Labs project that lets users refine image searches by clicking 'similar images' (where available) below a particular thumbnail.
- [News Timeline](#) is another Google Labs project that gives summary search results from selected publications in a timeline format, which can be customised by date and publication.
- An open source [3D plugin](#) for web browsers has been [released](#), enabling users to navigate web environments in 3D, based on an experimental standard called O3D. The purpose is similar to Khronos (see [TechNews 04/09](#)) but based on different underlying technology. Google envisages producers creating web applications, such as 3D games and data visualisations, that control O3D functions using JavaScript. [According to reports](#), Google states the new approach is complementary to Khronos, with the company expecting 3D support to be delivered natively (built into browsers) in a few years' time.
- Google Squared is another project, soon due for an experimental release through Google Labs soon, that provides a tabular view of factual data. The spreadsheet output can be customised by means of filters and facts can be checked by following links, although [it is reported](#) that results can be unpredictable.
- 'Public' data (currently a limited selection from the US) [can be presented on a chart](#) by entering a specific style of search query.
- [Search options](#). This new panel on the standard search page is available when results are displayed from 'Show options' near the top left (under the logo) and gives access to the features below.
  - Type of content - results from videos, forums and reviews can now be selected.
  - The timeline gives users an opportunity to narrow searches to dates mentioned within a web page.
  - The Wonder Wheel is like a mind map, so users can follow spokes from the current search to related searches.

### **Experimental, real time, Google Wave collaboration platform**

[Google Wave](#) is a completely new, experimental communication and collaboration platform. Although currently only open for developers to investigate, in anticipation of a public launch later this year, the product has created considerable interest.

Google intends to generate a new collaboration paradigm that is both real time (like instant messaging and microblogging) and which produces a publication trail (like wikis, blogs and email). Each thread is called a 'wave' and can be joined, replayed and edited by users at any point, enabling colleagues to quickly catch up and contribute. Discussions will appear in real time and documents can be developed by groups of authorised users, while images, presentations, videos and other files can be embedded or appended - all through a [single interface](#) that controls editing and provides an 'inbox' for updates and a list of the user's contacts. Individual waves will be available to embed into blogs and web pages for others to view or replay. The full

Google Wave interface will be a web application that runs in recent versions of most browsers, with a notable exception of Internet Explorer 8, which has yet to support the forthcoming HTML 5 standard. The [TechCrunch](#) and [Mashable](#) technology news blogs have helpful overviews of the features demonstrated at the recent Google I/O developer conference.

Google does not have fixed ideas about how the platform will be used, allowing developers to interact directly with the [application programming interface \(API\)](#) and take, modify and extend the [Wave protocol](#) through an open source licence. This open approach will allow system managers to install Wave on their own servers and will (Google hopes) encourage widespread adoption of the underlying technology.

It is unclear how Google Wave will contribute to education, but it has already produced ideas around collaborative learning projects, assessment for learning, e-portfolios, real time reporting and delivery of learning modules that involve debate and employ specially created gadgets to deliver content or to monitor learners' progress. Even if the technology can deliver many of these objectives, important issues may need to be addressed around security, authenticity and reliability.

### **Direct file sharing through the browser**

Opera Unite [has been launched](#) as an alpha (early test version) of an application that allows users to share files and information directly, without uploading to some sort of file sharing website or online service, effectively cutting out the 'middleman'. The Opera web browser has a smaller number of users than its counterparts Internet Explorer and Firefox, but the company claims that Unite will turn any computer running Opera (which could be based on Linux, Mac OS or Windows) into a simple web server. Nevertheless, users will not need to be running Opera to download from an Opera Unite service (access to which will be authorised by an Opera account), [according to](#) Christen Krogh, Opera's Chief Development Officer. To demonstrate the principle, the company has developed 'chat' and media player applications, but says that these are really there to prove the concept rather than as a showcase for the types of service that it hopes will be built.

Opera's goal is to put users back in control of their own data, so they are not at the mercy of web service availability or terms of service that lock data into a chosen portal. However, one of the greatest concerns with opening up access to files on your computer's hard disk will be security - both the danger of another user gaining unauthorised access to information and the risk of malware (such as viruses) being planted on your machine. Unite services will be associated with a 'sandbox' (a specially segregated portion of the hard disk), but this does not guarantee security. Another weakness will be the asymmetrical nature of many people's ADSL broadband connection, since download speeds may be 8Mbps or more, but typical upload speeds under 1Mbps, which makes two-way file sharing less practical. The music and film industries are also likely to be concerned about illegal copying of media files. This announcement has somewhat similar goals to Microsoft's Social Desktop ([TechNews 04/09](#)) and Google's much more radical Wave platform ([TechNews 06/09](#)).

## Prism promises desktop operation for web apps

Web pages are becoming web applications (see [TechNews 01/09](#)), with their own internal logic and navigation. This makes the browser interface less important, so that users may feel that the browser itself is a hindrance, especially on a low resolution netbook or small mobile screen. Running web applications externally to the main browser can put each application within its own operating environment, making it immune from browser crashes, and can remove screen clutter. Such environments are sometimes referred to as site-specific browsers (SSBs).

Mozilla Labs, the developer of the Firefox browser (as well as a range of other open source projects), [has announced](#) the release of a public beta (pre-release) version of its [Prism 1.0](#) desktop environment for web applications. For example, Prism enables users to run online email clients (such as AOL, Windows Live Hotmail or Yahoo Mail) as though they were separate applications, with their own shortcuts on the user's desktop, in the Apple Dock or Windows' Taskbar. Since they appear like standard applications to the PC, email applications in Prism can also be associated with the 'mailto' links on web pages, which might otherwise bring up an offline mail client like Eudora or Outlook. Web applications shortcuts may be helpful to system managers wishing to provide quick or protected access to services on the internet, although those services may indirectly grant wider access.

Mozilla says that a large number of different types of online application are already Prism 'enabled', including social software, blogging environments, word processors and photo editors. Prism can be installed directly into the Start menu (on Windows) or added as an extension to Firefox (on any compatible platform).

Adobe Air differs from Prism, in that it offers a specific programming environment in which web-connected applications can function and directly access the computer's resources, rather than taking standard web applications 'out' of the browser. Prism applications will need continued connectivity since the current version does not offer an offline environment, such as found in Google's Gears. Google's Chrome browser offers similar functions to some aspects of Prism by enabling desktop 'shortcuts'.

## Windows 7 and Server 2008 R2 for autumn 2009

The operating system is at the heart of every computing device, from mainframes, through servers and PCs, to basic mobile phones. New operating systems generally provide additional services to applications, increased security, native support for newer categories of peripheral device and an updated user interface.

Microsoft [has announced](#) that it intends to begin shipping Windows 7 (the successor to Windows Vista) and Server 2008 R2 (an update to Server 2008) this autumn. Some press reports have narrowed this down to a likely [October release](#). PCs with Windows 7 may be available from that date, but network managers are likely to opt to delay purchasing decisions until vendors have validated the new software as compatible with their networking products.

[Windows 7](#) will, according to Microsoft, improve application efficiency, security and the user 'experience'. In addition to supporting new types of hardware and updated



software, Windows 7 will have a virtual '[XP Mode](#)' (available as a free download for some editions) to provide backward compatibility for developers who have used features specific to the older operating system. Microsoft has made the near-final '[release candidate](#)' version of Windows 7 publicly accessible for testing and has released [details of the different editions](#) that will be available.

[Press reports](#) have given some indication of the specification that may be imposed for vendors wishing to install the Windows 7 Starter edition on netbook PCs: low power, low cost portable PCs will have single-core processors running at 2GHz or less; memory may be limited to 1GB; hard drive size to 250GB (or a 64GB solid state drive); and the screen is expected to be 10.2 inches at most. A Microsoft blog makes clear that the [Starter edition](#) will be able to run multiple applications, but will be limited in functionality, such as being unable to play DVDs, not supporting XP Mode and having restrictions in the user interface.

Ray Fleming, a Microsoft employee, has posted a range of items on the use of Windows 7 in education on the [Microsoft UK Schools Blog](#).

Apple's PC operating system, OS X, is also due for an upgrade (codenamed 'Snow Leopard') and developers continue to upgrade the open source Linux operating system kernel.

[Windows Server 2008 R2](#) embeds greater support for virtualisation, allowing up to 64 logical processors to work on different tasks. (Processor virtualisation separates software from the underlying hardware so that several processes can run in their own secure container, each appearing to have unique access to system resources, while sharing the physical processor and memory to increase utilisation.) Microsoft says that Server 2008 R2 provides a better platform for running web services, improved support for virtual desktops and includes updates to increase efficiency and scalability of server systems. Server 2008 competes with server products that include Mac OS X Server, Sun's Solaris, proprietary systems from HP and IBM, and various versions of Linux and UNIX.

### **Snow Leopard unveiled**

Apple [has unveiled](#) the latest version of OS X, its desktop operating system. Known as 'Snow Leopard', OS X version 10.6 builds on the previous Leopard release (OSX 10.5.7) and will be available as an upgrade from September. Apple particularly emphasises speed boosts in many of the native processes and applications bundled with the new operating system, with new 64-bit code for Finder, Mail, Safari 4 (the web browser) and other programs. Snow Leopard remains backward compatible with 32-bit programs on the Intel (x86) architecture, but no longer provides any native support for the older PowerPC processors. The update brings direct access to Microsoft Exchange servers, permitting email and calendar applications to automatically download messages and synchronise data with Exchange.

Snow Leopard introduces Grand Central Dispatch (GCD), which includes an application programming interface (API) and higher level frameworks to assist developers in writing code that runs efficiently on multi-core processors. (Writing

effective code for parallel processing environments is highly skilled, requiring programmers to understand issues like lockout - where two processor threads require the same resource - and how to optimise memory usage and the division of tasks between threads. GCD relieves programmers of these tasks.) The updated operating system also provides direct support for OpenCL, which is a programming language based on C that runs general-purpose programs on the graphics processor, taking numerically intensive loads away from the central processing unit.

No UK pricing has been announced, but an upgrade from OS X Leopard has a recommended US price of \$29 (around £18), with free upgrades for purchases made during a qualifying period.

Microsoft's latest consumer operating system, Windows 7, [launches](#) just a few weeks later, competing with Mac OS X, various forms of Linux and other software. Intel recently released its [Parallel Studio](#) suite, which has similar aims to Grand Central Dispatch, as a plug-in for Microsoft's Visual Studio development environment for Windows.

On the back of the main Snow Leopard announcement, Apple also [revealed](#) that its updated Mac OS X Server Snow Leopard software would be available in September, and [released](#) version 4 of the Safari browser.

### **Not all that's deleted is deleted**

Photos and other content posted to the internet may not immediately disappear after deletion, despite disappearing from a user's social networking profile or other page. [A blog post](#) from security specialists Sophos notes a specific incident on the popular Twitter microblogging service that created embarrassment to a well-known celebrity.

[Cambridge researchers](#) posted pictures to sixteen websites, noting the direct URL to the image, and then deleted the original. They reopened the URLs over a period of 30 days to see whether the pictures were accessible and found that images were still visible on five sites at the end of that month. This is possible because the files remain in photo server caches of the underlying content delivery network (CDN) after they have been cleared from indices that provide data for dynamic pages (such as profiles) and search results. The terms of service for these sites indicate that deletion may not be immediate, with Facebook likening the process to putting a file in the Recycle Bin, but the researchers question whether this approach is actually adequate under the provisions of the UK Data Protection Act 1998.

Social networks have been used to post content to embarrass or intimidate students, so it is important for learners to understand that the consequences of such actions may last even longer than they expected. Not only may content remain in caches and backups, but it can be copied to third party sites or be captured in archives, such as the (educationally valid) [Wayback Machine](#).

### **New communication software for severely impaired**

Learners with significant physical and mental impairments can find it extremely difficult to communicate meaningfully with parents and carers. *How was school*

*today?* is a Scottish package that enables users to capture the events of the day to provide a narrative to play back for others.

[Researchers](#) from Aberdeen and Dundee Universities and Capability Scotland developed a system that employs sensors, swipe cards and recording devices to produce the story of the day as the learner engages with normal activities. Teachers and carers at the school use swipe cards to identify themselves to the system and can record brief comments, while the disabled user selects 'smileys' and other icons to record reactions to people and events. When the compiled record is played back, the software generates sentences, using natural language techniques, based on the location, time and other data that has been captured. For example, if the user met a teacher in the hall at 1.30pm, the system could play back, 'I met Anne after lunch in the hall. She is nice.'

The system, which was trialled at Corseford School near Glasgow, will be used with a greater range of learners and will be extended to cover more situations and interactions.

## TechNews Information

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