Wireless networking in schools

A decision making guide for school leaders

September 2003

David Perry
Wireless networking in schools
A decision making guide for school leaders

This document is a joint publication of the British Educational Communications and Technology Agency (Becta) and the Specialist Schools Trust. It results from a survey of schools which have been using wireless networks, some for up to three years, and is aimed at headteachers and others who might be involved in a decision whether to ‘go wireless’. While it includes some technical detail, it is not intended to be an expert briefing. More technical information can be found at www.ictadvice.org.uk/downloads/whatis/wirelesslan_technical.doc

Lead consultants
Tony Parkin, Specialist Schools Trust; Julie Wilson, Becta.

Author
This publication was written by education consultant David Perry, with contributions from Danny Hopkinson, Mike Platt, Barry Smith and Jonathon Thomson.

Editor
Peter Chambers.

Acknowledgements
Specialist Schools Trust/Becta are grateful for the contributions made by the staff of schools involved in the survey, many of whom are quoted in this publication.

The Specialist Schools Trust
Founded in 1987, the Specialist Schools Trust (formerly the Technology Colleges Trust) is the registered charity which acts as the lead body for the specialist schools programme. The Trust is funded through a combination of private sector sponsorship, charges for services and government grant. Its mission is to give practical support to the transformation of secondary education in England by building and enabling a world-class network of innovative, high performing secondary schools in partnership with business and the wider community.

Becta
Becta’s role is to promote the use of ICT to improve and transform learning, teaching and leadership in schools and colleges.

This report is published with the financial support of the Department for Education and Skills.

© Specialist Schools Trust, 2002, reprinted with amendments 2003
Abstracting is permitted with acknowledgement to the source. For other copying or general enquiries contact:
Specialist Schools Trust, 16th Floor, Millbank Tower, 21-24 Millbank, London SW1P 4QP
Tel: 020 7802 2300 Fax: 020 7802 2345 email info@specialistschools.org.uk
Printed by Dexter Graphics, 3-5 Sandpit Road, Dartford, Kent DA1 5BU
ISBN 1-873882-83-1
Foreword

All schools face the constant challenge of identifying the most suitable new technologies and making best use of them.

Wireless networks are one example of technological development that most schools need to consider seriously. They connect computers to each other like a traditional network – and can connect them to the internet – but with radio waves rather than wires. This is important because it allows schools to connect desktop and mobile computing equipment in both existing classrooms and outlying accommodation, such as sports halls, without heavy investment in cabling.

This publication should help headteachers and other decision makers in primary and secondary schools to make the right decisions for their schools on the use of wireless technology. Wireless networking works well in all types of school, and if well planned and suitably introduced has educational as well as administrative benefits, often at lower cost than other networking solutions. School leaders should have confidence in this message because it comes from an impartial and objective source: evidence from a range of UK schools that have used wireless networks for up to three years, collated in a combined project by Becta and the Specialist Schools Trust.

It is not difficult to find publications extolling the virtues of particular new technologies. This one does more: it helps readers to identify and make the key decisions involved, such as what is required and how to achieve the benefits. And it has very practical advice on getting started – including sections on small scale pilots to minimise the risks, how to select and work with suppliers, where to get advice, and implementation tips from schools that have already been through the process.

Ivan Lewis MP
Parliamentary Under-Secretary of State for Young People and Learning
Contents

Chapter 1
Introduction

Chapter 2
Networks and wireless mobility
The case for wireless networks
Wireless means mobile computing – and mobile computers

Chapter 3
The benefits: increasing access to ICT
Beyond the classroom
Inter-school collaboration
Beyond the school
Some limitations

Chapter 4
The benefits: impacts on teaching and learning

Chapter 5
Key decisions
What is required?
Wired or wireless?
Wireless everything?
Critical mass – parallel developments working together

Chapter 6
Getting started
Why do you want it?
Small-scale pilots
Suppliers, and how to buy
Implementation tips from schools

Chapter 7
Practical considerations
Quick reference
  Buildings and architecture
  Bandwidth
  Standards
Other issues
  Health and safety
  Network security
Glossary

Annexes
A Sources of further information
B Suppliers
C Schools consulted
Introduction

Wireless networking works well in all types of school – and can bring major educational benefits. This is the powerful central message of this publication. Given a well thought-through strategy for its introduction, and especially when used in combination with portable computers, a wireless network extends the benefits of ICT for learning:

- To more children;
- In more subjects;
- In more areas of the school;
- For a wider range of purposes.

A wireless network can help teachers to:

- Work more efficiently;
- Better support their pupils’ learning through their own use of ICT;
- Use ICT to extract greater value from their teaching;
- Work wherever and whenever suits them best, in their school.

The flexibility of wireless networks and portable computers means that lessons using ICT in depth can take place in ordinary classrooms, allowing it to serve children’s learning needs and not dominate them, and to improve teachers’ confidence in innovating. Schools have found that the flexibility of wireless networks supports both teachers’ teaching and administration responsibilities highly effectively.

For smaller schools, wireless networking can offer a cheaper, more rapidly installed way of giving increased access to ICT school-wide.

For larger schools, wireless extensions to existing wired networks can bring campus-wide coverage with the flexibility to provide temporary additional coverage in unusual areas.

What is wireless networking?

Wireless networks connect computers to each other like a traditional network – and can connect them to the internet – via radio waves, without wires, using technology built into each user’s computer. Increasingly, the technology is built into laptop and handheld computers and if not, it can be added by installing a card and some operating software. All the benefits of the connectivity that networks bring are then available wherever the computer is used or installed, as long as it is within range of an access point. These are installed in the building either permanently or temporarily. To extend the network beyond the school, one access point has to be connected to the internet. Increasingly, we are seeing homes with more than one computer in use. For teachers’ or pupils’ home use (more likely to be feasible as laptops etc have wireless networking fitted as standard) their mobile computer can be linked wirelessly to a desktop PC by fitting a wireless adapter to the latter (cost about £60) and/or to the

If we have a special event, say in the school’s boardroom introducing parents to our use of laptops, we just bring in a mobile access point and we can rely on having uninterrupted use even if network traffic in adjacent areas of the school is heavy

Sawtry Community College
The six wireless iBooks allow teachers to use the teaching methods they know to be successful. Small group work, often supported by trained parent helpers, is an essential ingredient of any Foundation/KS1 classroom. The iBooks allow freedom and flexibility and are moved around the school on a rota/request system. The Leas Infant School

internet through a modem or internet gateway. The last mentioned is the most appropriate method when a home is connected to ADSL broadband – which is also becoming more common.

In special schools, when wireless networking makes ICT available anywhere, children can be given better access to their curriculum entitlement by taking facilities to them where they are needed. This can dramatically improve special needs children’s access to computing facilities and exploit the power of ICT to provide facilities dedicated to individuals’ requirements.

In schools short of space, mobile computers take up much less room on desks when in use and can be packed away into storage trolleys with chargers built in.

In all schools, wireless networking can include portable computers being used wherever they are needed, even outdoors, as well as fixed computers in remote areas of the school. Trolleys equipped with computers and wireless networking can be a mobile, shared resource that gives access to a school network and the internet. As a more flexible resource they can give better value for money than desktop computers. Schools using wireless networks report that when combined with portable computers allowing easy access to classes across the school, both the amount and the quality of ICT use surge ahead dramatically.

Beyond the school, wireless networks can support pupils and the wider community in networking with each other and with access to the internet.
Networks and wireless mobility

Very few schools in the UK need persuading that linking computers together brings many advantages. Schools have often started with a network for administrative use separate from the network accessed by their pupils. This was common because of fears that unauthorised people might gain access to sensitive information such as pupil records. However, different computers or even specific files on any one computer can now be made inaccessible to others, entirely reliably, through software solutions such as password protection. For this reason, up-to-date schools now have only one network and, for example, this means more efficiency for staff as any computer can give an authorised person access to information they need from any networked computer.

So with two key activities in a school, administration and learning, it suggests two network zones, and for each of these we need to add the extraordinary extra dimension that connection to the outside world brings via the internet. Admin can use this to share information with, for example, the DfES, parents or other schools. Teachers and pupils can resource their lessons with the amazingly rich bank of material that is available through the worldwide web, including the enormous National Grid for Learning information and resource bank and digital resources purchased with electronic learning credits (eLCs). And they can use email for educational purposes beyond the school, perhaps having pupils from across the world working together on projects. So using networks – including the internet, the biggest network of them all – is established as of enormous benefit to the purposes of schools.

The case for wireless networks

Running network wiring around school buildings is expensive. Running it around a computer suite in a single room is likely to be immediately cost-effective. But will this still be true if a link is taken across a playground to the sports hall for just a single teacher to use – for a minority of their time? Unlikely!

However, for a school to get the core benefits of a network, there is a ‘critical mass’ factor. It is no good making email the normal method of staff communication in a school if this makes life much more difficult for even one or two teachers. So a geographically limited network will prevent a school from taking the huge steps that would otherwise be possible and gaining the potential benefits.

To give distributed access, for all the efficiency benefits this brings, will require an adequate number of computers but with recent laptops for teachers and National Grid for Learning developments this is a disappearing problem in most schools. In the long run, limiting access to a school’s network to in-school computers will also be seen as a major inconvenience, but the internet brings answers to this problem too.
Wireless networking in schools

A handheld computer can still be logged onto the school network

Wireless means mobile computing – and mobile computers

Laptop computers, tablet PCs and smaller devices such as handhelds, web pads1 and digital assistants (PDAs) offer two advantages. They take up less space in classrooms and staffrooms; and they can be used in other locations, such as for pupils’ fieldwork or teachers’ lesson preparation at home.

These practical advantages make a major difference in the educational context, especially when combined with wireless networking. However, there are costs: laptops cost more than desktop PCs of equivalent capacity and tend to be more fragile. That said, the schools surveyed for this report overwhelmingly favoured the use of laptops with wireless networking.

As yet, few schools have used palm-sized devices with pupils, though the slightly larger handheld computers date back to Psion devices of a decade ago. These have been widely used for dedicated applications such as data-collection for science. More recent handhelds, using Windows-CE, have not proved a great success in the business marketplace. However, some schools are using them very effectively, either limited to the handheld’s own resources or backed up considerably by applications held on a school server (see the Huntington School exemplar on page 9).

However, the majority of schools surveyed use full-size laptops purchased by the school and allocated to classes or departments that they can be sure will make good use of them. Often they are stored in trolleys and used in more than one room. In smaller primary schools such a set of laptops may be used throughout the school. However, stairs cause problems as trolleys are heavy.

Some schools allocate a set of laptops or PDAs to a year group or key stage. Some allocate them to specific children to use exclusively for a year or more. This form of personal ‘ownership’ has advantages, but is difficult to achieve. Some of the survey schools helped pupils to buy their own laptops or rented them to pupils for a monthly fee. Some have an e-Learning Foundation link to help with personal ownership.

Radio based (Wi-Fi) wireless networks and mobile computers go hand in hand. The mobility of the computer is supported by the network link continuing to work as you move from place to place, though ultimately limited by the coverage your school offers. In time, it is possible that whole communities or the whole country could be covered by wireless access points. Then you would be able to sit almost anywhere and work, connected to all your resources and communicating with others as you go. Several thousand Wi-Fi ‘hotspots’ have been set up already for wireless access to the internet in public places such as coffee shops and waiting areas in stations and airports and these are set to increase in number. For the time being, however, the first priority is to achieve this flexibility throughout the school, and secondly to teachers’ and pupils’ homes.

One of the big advantages of wireless is its relatively low cost. An individual wireless access point can cost less than £100 and some smaller schools may be equipped for under £20,000 – though the cheapest equipment may be less effective. This compares favourably with wired networking. However, of course there is a catch. For the present, wireless are not as fast as wired networks, so large files like multimedia or video streams, or too many people active in a small area, can slow them down unacceptably. This is not likely to last for long. Standards approved for Europe in 2003 (see chapter 7) have brought about five times the speed of connection. We can be confident this trend will continue. Over time, wired networking is likely to continue to be valuable though usually supplemented by wireless extensions.

1 see www.becta.org.uk/etseminas/presentations/presentation.cfm?seminar_id=13 & presentation_id=26
Wireless networking in schools

The benefits: increasing access to ICT

Above all else, schools with wireless networks – in whole or in part – stress that the main advantage is increased access to ICT. Used with mobile computers and managed well, their flexibility brings a range of advantages which encourage and facilitate greater ICT use. Computers can be in use where they are needed, when they are needed, with little waste of time or resources.

Importantly, wirelessly linked portables take the emphasis away from ICT and keep it with the main concerns of a lesson. In the wireless world, the laptop computer is the learning toolkit. Like textbooks, maps, a protractor or a pair of compasses, it is just another resource to draw on (though an immensely powerful and multitasked one). The technology becomes transparent, restoring the emphasis on subject content, curriculum context and skills development.

The widespread benefits of wireless include many efficiency gains:

• No empty ‘home’ classrooms while the class works in the computer suite;
• All computers that a school owns in use for longer and spread around the school;
• All teachers can become more confident and competent in ICT;
• Inclusion – a single computer can be brought to where a pupil needs it; imagine this in a special needs room, hospital school, or school for the physically handicapped;
• More flexibility in response to problems: if a laptop computer fails, another can be brought in from down the corridor; if a computer suite is double booked, a set of laptops can be used elsewhere;
• Teachers are less worried when working with new technology if they are in their own teaching room rather than a remote computer suite;
• A wireless network in one or more areas, especially if shared, can free computer suites for other uses;
• Wireless networking is cheaper to install than wiring;
• A wireless network with laptops saves space. DfES architects advise that once a computer: user ratio of 1:5 has been achieved very few schools have the space for further ICT suites.

Teachers can take their full teaching resources with them in their laptop, with access to their files on the school’s server or the internet through the wireless network, so they can cope with their administration loads better by using their laptop, tablet or PDA anywhere in the school – catching catching up on email in a ‘cover’ lesson or accessing pupil records in a precious moment during morning break.

Mobile computers can make a dramatic difference to the integration of ICT in lessons. In one observed mathematics lesson at The Cornwallis School, the children were sitting at desks in their normal way, all facing the front while a data projector was used by the teacher on the (non-electronic) whiteboard to launch the lesson. They worked some of the time in their books, taking a laptop from the trolley when ready, sharing this with their partner as needed. Some finished the specially prepared maths game set for them on their
Any classroom can become a temporary ICT suite

We chose wireless networks to give flexibility of use of equipment in non-IT-specialist rooms

Rodborough School

laptop and went immediately to a research task using the internet.

This was an outstanding example of the full integration of ICT into an ordinary lesson, with several extra advantages: specially prepared tasks being available to allow pupils to work at their own rate; tasks selected by just clicking through the network; everything prepared in advance by the teacher herself; varied levels of difficulty possible through adapting the basic task to suit special needs; and the flexibility to go to other resources, in the school or elsewhere, as and when an individual was ready.

Using computers in an ordinary classroom is different from booking a suite, and reduces the time wasted by children moving around the school. As a mathematics teacher at The Cornwallis School pointed out: ‘Using laptops in your own classroom or department makes it a much more normal situation. The children are in their familiar place, the laptops can be used alongside their normal books and other resources, and I can use them for as short a time as I like. Using a computer suite, I have to book it in advance and feel obliged to use the computers for the whole lesson.’

Reduced costs of installation and space saving from portable computers on wireless networks can offer particular advantages to primary schools, especially as finding space becomes increasingly difficult in the face of rising computer to pupil ratios. St John’s CE Primary School, Kent, had no space for a computer suite; it had a wired network with one computer in each class at KS2. The addition of wireless networking and laptops allowed a class teacher to use ICT to support other subjects when they needed to.

The technology comes into the classroom and is part of it. It can be used by just one or two children or as many as the whole class.

Unsurprisingly, wireless networking brings no problems for pupils. They live in an age where everything is remote-controlled – cars, TV, video, stereo etc – so this is really no big deal, and schools have found their pupils just want to get on and start using the equipment.

Perhaps more surprisingly, schools researched found that teachers are less resistant too. Staff doubts about this ‘magical’ system were soon overcome.

Beyond the classroom

Many schools reported that they exploited the freedom brought by mobile computers on wireless networks by extending opportunities outside their classrooms. This included:

• Children working individually in other places: the library; common rooms; corridors; nooks and crannies. This might be in lesson times or for lunchtime homework sessions, for example;
• Using temporary classrooms more effectively by including them on the network and taking laptops to them;
• Using laptops, tablet PCs and PDAs where computers were not previously available – in sports halls and drama rooms;
• Using mobile computers around the school grounds – for environmental science work, or on the games field.

Inter-school collaboration

Some specialist schools support their local primaries by helping them with wireless networking provision, as the following exemplar shows.

2See the case study ‘Greenwich & Kent Schools’ at www.microsoft.com/uk/windowsxp/tabletpc/evaluation/casestudies/ which also has a short video of the pilot at Cornwallis
Exemplar 1

Wireless networking aids collaboration between secondary and primary schools

A project to develop wireless local area networks (WLANs) in two schools in York – a primary and a secondary – included personal ownership of laptops in the secondary and trolley-based kits of handheld computers in the primary, with ‘wireless’ printing. The project’s main objective was to evaluate the effectiveness of WLAN technology in supporting ICT in the classroom and to find out how it affected teaching and learning.

Each learner would have individual access to a laptop or handheld PC, and lesson plans aimed to achieve maximum curriculum value from the WLAN technology. It was felt important to explore new approaches to ICT in the classroom with this technology, rather than simply to facilitate current practice. Individual ownership by the learner would avoid the need to take the units to a learning group. The longer-term objective was for ‘anytime, anywhere’ (school and home) learning, through online access to applications (see www.uniprint.net) and data (see www.webstore-ed.net).

Background

Both schools are in the City of York Education Authority. One, Huntington School, is a Technology College with 1800 pupils, 100+ teachers and 300 PC desktops spread over 10 ICT suites. The other, Westfield Primary School, 700 pupils, 30 teachers and 40 desktops including a suite of 25. Both schools have whole school network access to current curriculum applications from all desktop PCs and 2Mbps broadband internet connections. Several curriculum areas have electronic whiteboards, and portable data projectors are available to most other classrooms.

The staff at both schools have completed their NOF ICT training and are moving from the adoption of prescriptive ICT resources to the adaptation of them to meet their particular curriculum needs. Without this level of staff ICT skills and awareness, the project outcomes would have been limited.

A signal strength audit established the number of access points needed to cover the classrooms that would require WLAN connection.

Reasons for implementing wireless technologies

The schools considered that continuing to fill classrooms with desktop PCs was not a valid option. Additional ICT suites would take over more classrooms and create complex timetabling issues. In the case of the primary school, space was at a premium, so ICT needed to be taken to the pupils in their classroom. The ultimate objective was individual PC access, or at least two pupils to one PC.

Choosing suppliers

ICT support for schools in the York Education Authority is mainly provided by a lead school support unit. This delivers managed services to the schools to support all curriculum and administration requirements, including managing connections. This ICT support service was invaluable as it included evaluation of several manufacturers’ equipment, site survey support and help in configuration.
Wireless networking in schools

The aspects considered in determining the suppliers included:

- Price;
- Performance;
- Signal strength and range;
- Durability in the classroom;
- Adequate data encryption;
- Ease of use;
- Warranty provision;
- Portability;
- Ease of resource management for the teacher.

The schools realised that low product prices had to be balanced against the full support service. Acer Travelmate laptops were used in the secondary school and NEC Pro790 handhelds in the primary, both connected to Buffalo Airstations and individual PCMCIA wireless cards. HP350cix wireless colour inkjet printers provided simple local wireless printing via infrared ports.

The local managed services provided on-site support for the whole system with guaranteed next-day response and training for teachers and school support staff, including first-line fault diagnosis.

Implementing the wireless networks

In the secondary school a 10-laptop WLAN suite complemented smaller desktop suites where individual access was not achievable. Technicians had to transport the suite to a classroom promptly, as only five minutes was allowed for lesson changes. The primary school used a full class set of WLAN handhelds.

Neither school thought it necessary to wireless-link the whole campus. As long as the suite of laptops and handhelds remained together, the access point roamed with the suite and simply connected to the local area network (LAN) via a network cable on arrival at each classroom.

Issues raised

In the secondary school, transporting and charging the laptops caused problems, as the charge could only be guaranteed to last for one lesson, and five minutes between lessons was not enough time to de-install and re-install the suite.

Security of the resources proved difficult, with insecure classrooms and access to the classroom in the following lesson disrupted. Too much technician time was taken up with allocating these laptops. Making individual students responsible for maintaining the charge and operational status of ‘their’ laptops seemed to be the solution. ‘Anytime, anywhere’ access was not considered to be achievable without individual ownership.

In the primary school the transportation of the suite was achieved with a ‘netcase’ travel unit (believed not to be commercially available now), which contained the handheld PCs, charging facilities, wireless access point and infrared printer. This worked well, with the teacher managing to take the units to the lesson, distribute the computers to the learners and set up the printer quickly.

Lessons were clearly more effective as a result of the true portability and wireless connectivity of these handheld PCs with the pupils (Y6) readily taking to the new...
touch screen and stylus technology. Access to online multimedia was via the internet with local access to ‘office’ applications either on-board or through a powerful laptop terminal server.

Infrared printing was easy and effective as pupils took the handheld computers to the printer.

The discussion about individual ownership considered purchase costs, equity of provision and parent funding options. The decision was to provide parents and pupils with a lease including managed service. When individual ownership of portable WLAN devices becomes the norm, the school will provide the connections and application licensing per pupil (not per workstation). Access to online data storage and applications will be necessary for home as well as school access.

Outcomes

The teachers immediately recognised the value of taking ICT to their learners. Individual ownership (including for the teachers themselves) resolved problems with transporting classroom sets. The portable PC options avoided ICT taking over the lesson.

The total cost of ownership was highlighted as fundamental in working towards individual ownership. The small handhelds appeared to be more successful in this respect. They also held their charge for longer and were easier to transport.

Students and pupils respected the opportunity to use new technology and did not abuse the equipment or service.

The value of such portable ICT was clear. It provided better support for teaching and learning than the previous setup using desktop computers, except where more power was needed for special applications such as in music. The goal of individual ownership of a truly portable WLAN access device at low cost was substantially achieved, including ‘anytime, anywhere’ access to the users’ applications and data.

Beyond the school

Some schools are using wireless technology to reach outside the school grounds, with external aerials linking nearby local homes.

One school, Jeff Joseph Sale Moor Technology College, Cheshire, won the ‘Most Innovative use of Technology’ at the Networking Awards 2002 with establishment of an open-to-all wireless access point located in a council house in the centre of a local estate. The wireless network is intended to give network access from anywhere in the college and up to 5km into the local community. Extension of the network into the community is intended to give students access to the internet and their work on the college network, and to give internet access to residents in the community to support lifelong learning and in particular the LearnDirect initiative.

The alternative is to let pupils use the internet to access the school’s network from home to make their full range of school-provided resources available to them for homework as well as in school. But this relies on them being able to pay for internet access. If the school’s system gives them free access to the internet outside school hours, the marginal extra
 costs are borne by the school and it ensures better value from the investment.

Lifelong learning is developing in parallel with internet access and online learning in schools. A number of largely separate schemes are addressing different target groups for the same purposes:

- Wired communities – saturating areas with free or low cost internet access through TV set-top boxes or computers;
- UK online – the umbrella which covers many national government initiatives to bring small businesses, local government information and transactions (eg, paying parking fines and council tax) and community learning online;
- Community Access to Lifelong Learning (part of UK online) – bringing access and training to underprivileged people in the local government wards with the highest indices of deprivation.
- The People’s Network – providing open access to the internet in libraries.

Some schools are involved with several parts of this government push towards the information society. Wireless networking can help ease access for many people in these schemes.

Some limitations

Wireless networks, like all technologies, have their limitations.

Black spots

There are likely to be some black spots – areas without access to the network – and it is difficult to predict where they will occur. More access points can be added but there comes a point where this is not cost-effective. Mobile access points can reduce additional costs while overcoming dead areas.

A basic site survey simply involves placing a mobile access point in a variety of positions and then walking around with a wireless-equipped laptop to see where the signal will reach. Or two laptops can be used. It is essential that this is done – by companies wishing to tender for an installation contract – before any number of points are installed. However, school staff may undertake this themselves for a pilot study using a single access point. Wireless will always work across a single room, though careful positioning of the access point is advisable.

While one access point per classroom is a reasonable minimum, schools have found that about eight computers is the optimum number to be supported by each access point (this is known as the contention ratio). However, fewer computers per access point will support the regular use of larger file sizes.

Depending on the construction of the buildings, some quirks may be expected.

Slow speed

Wireless networks are normally between 3 and 10 times as fast as wireless at the time of writing (summer 2003) – a nominal 11 or 54Mbps wireless [802.11a and 802.11g give actual rates of 25-30Mbps (a) and 10-20 Mbps
(g) versus 100Mbps on wired ethernet. The relatively slow speed of current wireless networks can rule them out for realistic use of multimedia files, video streaming or other large files such as those from graphics or computer-aided design (CAD) programs. Although many schools do not yet use these applications, wireless networking should cope reasonably well if a system is installed that can be upgraded - transmission speeds will undoubtedly continue to rise over time. Wireless is offering 54Mbps now, but the technology for speeding up wired transmission by a factor of 100 (Gigabit networks) is already available.

**Network management**

Any network needs to be managed, starting with being set up suitably for the usage expected. This should be done by the company installing it, providing they have experience of working with schools. And then, on a continuing basis, at the very least, files need organising, redundant ones need to be periodically cleaned out, and new applications need to be added. Once initially configured, none of this is different for wireless networks than for wired.

To ensure a reasonable level of security, on older equipment the WEP facility (wireless encryption protocol) that is supplied with the wireless system software should be enabled. For schools, this is likely to be an adequate level of protection against interference from other local users of wireless networking. Newer equipment should have WPA (Wi-Fi protected access) on the Wi-Fi certification label, which is a later and improved security technology. These precautions are often overlooked, as many wireless units are supplied with their security option turned off.

*The benefits of wireless networking will never be fully realised unless accompanied by a significant and continuing investment in staff training.*
Wireless networking in schools

4

The benefits: impacts on teaching and learning

The laptops have made it easier to address individual and group needs.

St John’s Primary School

Dorrington’s wildlife area is on the school network

The schools surveyed reported very significant benefits, many of which are set out in the previous chapter. We have reached a stage where good access to ICT (along with a number of other factors) has been conclusively shown to bring broad educational benefits (see for example the ImPACT2 study www.becta.org.uk/research/reports/impact2/index.html).

These technologies are improving all the time. Laptops are getting lighter, faster and more fully equipped as well as less expensive, PDAs are becoming more powerful and versatile, tablet PCs are breaking the link with keyboarding. Screens are getting brighter and clearer and batteries are slowly progressing to last longer. Few schools have yet used palmtop computers or PDAs (personal digital assistants) to any extent, but some have experimented with the business functions that these offer including diary/calendars (for individual timetables and homework logs), individualised databases and internet connection. As the technologies move forward we can expect the enthusiasm of these schools to increase and many more to join the wireless crusade.

The improvements in access to ICT brought about by a combination of mobile computing and wireless networking often exceed schools’ expectations and lead to considerable excitement and commitment.

The following case studies give some of the flavour of this in two schools, primary and secondary.

Exemplar 2: primary

Mobile and static laptops with WLANs supplement computer suites

In four years Dorrington Primary School has moved from a low base of staff expertise, facilities and curriculum use, to the point where the children and staff use ICT wherever teaching and learning are taking place. Staff and children show confidence and enjoyment when working with the laptop computers.

Dorrington is a large primary school with three classes per year group. Undoubtedly the size means greater flexibility in financial resources but it also means a large site with six ‘temporary’ classrooms outside the main two-storey building, which has a convoluted layout. Like many schools, space is at a premium, and there is no spare area to dedicate to a computer suite.

After four years of investment and development, Dorrington operates 32 laptops in two mobile suites of 16, with another 16 located permanently in classrooms, which the teachers are encouraged to use at home. There is one desktop computer in each classroom also connected to the network.

The suites are first timetabled to each class in rotation to meet the requirements of the ICT national curriculum, and thereafter available as a bookable resource. They are used to enhance literacy and numeracy by accessing the internet for activities on the Birmingham Grid for Learning (BGfL). In addition the science co-ordinator, Carol Shotton, has collected a bank of ICT activities that support...
learning in science from reception to year 6. These activities are successful largely because of the portability of the wireless network:

- Using software which models electrical circuits;
- Data collection with digital cameras in the wildlife area across the playground;
- Results analysis and presentation of reports.

In all these activities the staff and children have access to the technology where they need it – at the learning place.

ICT co-ordinator Ken Holmes is a KS2 class teacher with a half day per week release for management and curriculum development of ICT. He is supported by a consortium technician, shared with six other primary schools. The technician spends around 1.5 days per fortnight at Dorrington.

In 1998 Birmingham LEA was committed to spending the bulk of its NGfL funding on providing access to the internet for all its schools. Each school had to decide how best to deploy this. At the Birmingham ICT show that year Ken Holmes met national educational ICT provider XMA, which had recently introduced wireless networking. A full site survey revealed where the cabled part of the network should go and where the access points would need to be to provide complete coverage. With no network infrastructure, the school had the benefit of working from a clean sheet, which facilitated a properly designed and integrated system.

**Choosing wireless networks**

Before making the commitment to use XMA the school contacted other well known educational ICT providers but none were able to recommend a solution at the time. Even the local authority had little experience in the field. XMA was a ‘managed services’ provider accredited by Becta. When the choice of laptop manufacturers was to be made, the school felt that it should go with Toshiba, with whom XMA had already established a good working partnership. The choice of WinSuite 2000 as the lock-down software was again guided by XMA, and it also recommended a cabling company.

These decisions meant that the school would only have to deal with one project manager and the problem of buck-passing by providers when things got difficult was eliminated. This partnership between the school and XMA has proved enduring.

**Implementation**

As a ‘reference site’ for XMA and Toshiba, the school obtained a significant discount on the hardware in exchange for allowing itself to be featured in advertising material for the companies, providing a person to help on XMA’s BETT stand, and hosting a stream of visitors to the school.

So with a £35,000 NGfL grant (enhanced because the LEA nominated them as a Pathfinder school in this area) and £15,000 of school funds, the system provided:

- Cabling and infrastructure;
- 16 laptop computers with WinSuite 2000 lock-down software;
- 16 desktop computers;
- A 2Mbps link to the internet through Birmingham LEA;
- A 7Mbps wireless network with six fixed and two moveable access points, which would eventually incorporate all teaching areas, the staff room, assembly hall, playground and wildlife area;
- Locally loaded software applications with group log-ons and file areas.

By 2000 the demand to use the laptops from staff was so great that it was clear...
more machines would be necessary. This would alleviate the carrying up and downstairs that had to happen to provide access on both storeys of the building.

A lease scheme was entered into with 16 more laptops, a data projector and two trolley cupboards, which would house and recharge the computer batteries.

In 2001 demand increased as the ICT co-ordinator encouraged the staff to take the laptops home to create teaching materials. The school used another £13,200 from its budget together with a NGfL grant of £4760 and a grant obtained by a school governor of £5000 to purchase 16 more laptops and another data projector. By this time the ICT staff had enough experience to configure the machines themselves, avoiding additional setup costs.

There were great problems with the batteries in the second set of 16 laptops, to the point where they had to be used connected to the mains. So they were all permanently allocated to classrooms and the class teachers became responsible for them, just like any other classroom resource.

The future

The wireless network is now well developed and, with an increase in internet traffic, this year’s NGfL grant will be invested in an internet proxy server, which will speed up access to internet pages. As the price of laptops falls, the school hopes to have enough funds to invest in a new suite every year. Ultimately it might be possible to have a suite of 16 laptops shared between two classes or even each class to have its own suite.

The school hopes to be part of a project run by BGfL and XMA into making video conferencing across wireless networks viable, something that has proved difficult so far.

The technology behind wireless networking is likely to change significantly over the next couple of years, which will raise compatibility issues. But, if the technologies are not compatible, the school will simply run another network alongside the existing one. ‘Either way wireless networking will continue to provide for our needs,’ Ken Holmes maintains.

Effects on teaching and learning

As one walks round the school and into classrooms it is very apparent how at ease the children are when using the technology. Tarvinder and Shisan are in Y5 and as they browsed the internet for information on Buddhist celebrations in response to some stimulus questions in a Word file set by class teacher Alison Gardener, they clearly thought it odd that anyone should ask about the advantages of the laptops over going to an ICT room. These students are well beyond considering computers as special equipment. They simply use them to help in their day-to-day classwork.

Nikki Johnston is a year 1 class teacher who regularly uses up to six laptops for children to work on word-processing-based activities.

The setting up of the computers takes time with young children if the teacher has no classroom support and this sometimes means the teacher has to work with fewer machines.

Vikki Metcalf is a reception class teacher who uses a full suite of laptops with her children. This is easier for her to set up because she has a classroom assistant to help unpack the computers and find the appropriate programs. The children have used PaintIt to complement their pattern design work and to experiment with mark-making in a new medium. The class have also accessed parts of the...
Birmingham Grid to label parts of the body on screen.

Other teachers comment that access in the classroom has greatly improved the children’s computer skills. Some of the secondary schools that Dorrington feeds confirm that using the computers for everyday research and tasks has improved pupils’ general ICT capability.

One teacher comments that she has also become a learner and this has revitalised her teaching. ‘I now prepare materials which I put onto the network for my class to access during literacy sessions.’

However, another complains: ‘I look to use the network as a tool. If only I had my own projector, I’d use the networked desktop in my room for a lot more whole class teaching.’ These comments reinforce the point that if the resources are made available in the class room, teachers will make them work to their children’s advantage and then demand more as they see the benefits.

Headteacher Pat Woolliscroft sees the laptops motivating children to work on literacy. The children’s work and SATS results show improvements in spelling, punctuation and creative writing, although it is difficult to quantify what proportion of the improvements are due to increased use of ICT and how much is due to other initiatives over the last four years, such as the literacy strategy.

Numeracy indicators have also shown an improvement. Some students have regular access to the Global Learning integrated learning system, which the school believes has had positive results.

‘We have to use the technology,’ says Pat Woolliscroft. ‘Many of the children use ICT at home both in their school-based tasks and in their recreation and they expect to have access to these facilities in school.’

Exemplar 3: secondary

Access to ICT with a school-wide WLAN and laptops

‘Any space is a learning space,’ says Alan Stevens, Associate Principal of Sawtry Community Technology College, about the change brought about by their wireless network.

The most remarkable thing about this network is how unremarkable it is. That is to say, it has caused very few problems, is utterly reliable and, relatively, cost little to install. It was put in to link the rising number of laptops being used in the school to the main school network, just like the school’s suites of desktop computers.

Bandwidths

The network was first installed in 1998 and as a pioneer of wireless the school is now running with a system that is behind the times. The capacity of the link is only 3 megabits per second (Mbps), whereas current installations run at 11Mbps [later increased to 54Mbps - ed]. What does this mean in practice? Generally, not much: even the exchange of ‘heavier’ items like graphics is fast enough not to cause any noticeable wait. But this is dependent on the number of users competing for the use of any one node on the wireless network linking them to the school’s wired 100Mbps network.

However, especially at only 3Mbps, internet use must be recognised as demanding for wireless networking, especially in an institution of any significant size.

I find it easier to use the suite of computers rather than a single machine because all the children want it to be their turn every lesson!

Vikki Metcalf, reception class teacher, Dorrington Primary School

You don’t always need the same power or bandwidth - you just start from the function that people need to carry out: for example, getting basic internet access or storing their word-processing files

Alan Stevens, Associate Principal, Sawtry Community College
Total coverage and flexible use

The first task for the network to become recognised as reliable and flexible was to establish whole-school coverage. The relatively modern, mostly single-storey, building required 26 nodes or access points. However, as the number of users rose so some areas proved to be black spots in the network’s coverage and some more unusual needs were revealed. Adding access points to cover black spots is easy and cheap. The school's technicians do it, as the equipment configures itself and only requires to be tapped directly into the wired (ethernet) network and to be provided with 13amp mains power.

One of the more unusual examples is the school hall. It is not normally used as a classroom, but can be full of pupils with all or many needing network access for a special event. To achieve this, one access point gives coverage for normal use and a second or even third mobile access point can be plugged in on demand.

Another use for these mobile points has been special presentations to outside groups by senior staff in the school’s meeting room. To make sure that a sudden rise in demand from nearby classrooms does not slow down the connection during an important presentation, a mobile point will be brought in temporarily. The speed of the wireless network is determined by the number of active users on the particular access point serving a user's location. If coverage by more than one point overlaps, then the computer will automatically select the fastest connection route. The wired network carries the traffic around the school as a ‘backbone’, feeding and drawing from the central server(s). However, there is a natural limit to expansion by increasing the number of access points and Sawtry is already seeking a way to upgrade its whole system to a broader bandwidth.

The most important other piece of the jigsaw for Sawtry is its use of a large number of laptops. The wireless network was initially installed when the school started on the ‘anytime, anywhere’ learning project. This has continued and the number of pupils using laptops has increased. Every member of the teaching staff now uses a laptop. They carry out registration on their networked laptops and email is the core means of internal communication in the school.

Sawtry puts a high premium on the dedicated personal use of portable computers, and wireless links are a natural adjunct to their use. But laptops, like networking, do bring extra burdens for a school. Laptops cost more than desktop PCs, tend to be more fragile and do not match the specifications of equivalently priced desktops. However, they bring major advantages in the educational context, and combining them with wireless networking does much to realise their full potential.

Clearly a wireless network is a natural partner to a mobile computer as it allows the advantages of networking to be as portable as the computer – within the limitations of the area covered by the network.

Ownership

Sawtry’s commitment to any laptop remaining with one individual rest largely on the term ‘ownership’. This is not meant in financial terms: one person has a laptop dedicated to their use exclusively – at least for a substantial period of time – and as a result they feel a sense of belonging. Their screen always looks and feels familiar, they know exactly where they keep their data files and can go to what they want quickly and efficiently. The little quirks of the machine, their software or their own ways of doing things are no trouble to them as they are so familiar and they know how to avoid difficulties.
When their laptop is linked to the school’s network, it also means that when the user turns to a desktop machine, perhaps in a classroom suite, the files they store on the server are available to them exactly as on their laptop. This familiarity and security encourages confidence and encourages teachers in particular to use ICT more and more effectively.

**Wired networks**

Having achieved 100% coverage of the school, Sawtry staff see the need to exploit further the potential that a flexible, ubiquitous local network and internet access offer and this will no doubt take some years to realise to the full.

The school has found that only 6% of its year 11 have no PC at home, and most have internet access.

Email is the primary method for staff-to-staff communication. All staff read their email at least twice a day, making communications much more efficient and reducing their workload. Already though, by making the sharing of resources by staff easier and quicker it has found that more effort goes into collaborative development, resulting in higher quality resources as drafts are worked on by several people. This should in turn help prepare the staff for more sharing of resources using the school’s website, and for more curriculum innovation.

Alan Stevens now expresses regret that he did not involve all teaching staff from the start of the laptops/wireless networking project, as he feels in retrospect that it slowed down curriculum developments by about two years.

Professional development support has been essential: one teacher has been made responsible for continuous professional development in ICT, and is about to start using a new system to support this work (www.schoolkit.com). Learning support assistants are trained through the European Computer Driving Licence system and ICT is an element in of the school’s Investors in People programme for all employees. Cleaners are offered ICT training, and the caretaker has email to integrate him into the school’s communications. The school hosts a UK online centre for community learning.

**Future plans**

The school’s website is undergoing major redevelopment to make its intranet accessible from outside school and outside school hours. The main focus will then become providing resources for pupils. Experimenting with new mobile phone technologies will be a part of this, allowing the ‘anytime, anywhere’ concept to be considerably expanded. If these technologies prove cost-effective and to have good geographical coverage, they could be the wireless method for use in school or anywhere else.

Resolving the situation whereby some pupils have personal laptops and others do not is also an issue. The current leasing arrangements end with a ‘peppercorn purchase’. The school is investigating means of continuing the equipment’s use. Sawtry confidently expects demand to go on growing for some years, both in numbers of users and in range of uses, as staff and pupils become more confident and experienced.
5

Key decisions

What is required?
As with wired networks, depending on the complexity of the system and numbers of computers, networks may be linked with or without a central server. However, in schools a server is highly desirable, even with a very limited number of computers, to use for managing the network and users’ files and for controlling access to the internet. You should ensure that the network and its components conform to WiFi standards which ensure compatibility between equipment from different manufacturers.

Each computer must have either a wireless network card or, in the case of newer machines, may be ‘wireless enabled’ when purchased – which is preferable. The cards for laptops and handhelds go in slots, usually projecting to provide an aerial (which can be vulnerable). Some PDAs use a card, some have the networking capability built-in and others have a slide-on jacket connecting to their expansion slot. Desktop PCs can have a small external sender/receiver unit (about the size of a mouse) plugged into a USB port or can be fitted with internal expansion cards (which are preferable in schools). The internal cards for desktop computers often also require a (PCMCIA) card as used in laptops.

A number of access points (or base stations) are installed which send and receive signals from the computers. The number needed depends on the number of computers, the size of the area to be covered, the physical arrangement of classrooms and other factors such as the amount of steel in the building. It is possible to start with one or a few access points to give limited coverage for a pilot trial. It is also possible to purchase mobile access points or even to include these in a trolley where a set of laptops are stored and charged, giving a stand-alone and mobile solution to be wheeled to wherever in the school it is wanted. While this would network the set of laptops together, further arrangements are needed to link it to any other in-school network or the internet.

When combined with a wired network, access points are installed as necessary, each of which is plugged into the wired network. These access points link the computers used in the area covered and route connections through to the school’s server. Use of the school network is then the same whether through a wired-in terminal or a wireless access point.

One access point may cover several classrooms as well as an area around them. This has implications for security of data (though not if the latest WPA security is in place) and for use in unconventional settings such as in a corridor, storeroom or on a bench in the yard. Sometimes rooms above or below can link more effectively than rooms alongside. If more than one access point is used, they automatically share the networking load and access to a server is as if the network were wired.

Separate buildings are usually linked by special directional wireless ‘bridges’ at each end, each of which also includes an access point for connection inside its building.

Other special access points called ‘gateways’ are used to link to the
internet, through a phone line (for dial-up or cable modem, ISDN or ADSL connection). These have a ‘router’ (pronounced: rooter) built in to switch internet signals to and from different computers on the network. Alternatively, if the school has a wired network, the wireless access points link to this and then to the internet, which is probably preferable for large schools.

**Wired or wireless?**

So what are the advantages of each of these approaches? Both use ‘Ethernet’ protocols but as has already been stated, wired networks are much faster, so can carry more traffic and support large files acceptably. They may well maintain this advantage for the foreseeable future as, being a more mature technology, they are upgraded in larger steps.

**Wired advantages**

- Wired networks support more users and can transfer larger files such as computer-aided design, graphics, video and multimedia;
- Wired ethernet is a mature technology that is very reliable and well understood;
- The necessary technology is built in to almost all new computers or can be added at very low cost (approx £15 for a desktop computer);
- Much faster speeds are becoming available;
- Routing and switching boxes have come down in price and are freely available;
- Servers, filters, firewalls and the like are all well proven and robust;
- Wired networks provide a powerful core to which wireless extensions can be added.

**Wi-Fi wireless advantages**

- Flexibility of location – in a room, around other rooms, in corridors, outside, elsewhere (eg, coffee shops/airports);
- Flexibility of scale: mobile access points can supplement fixed ones and more fixed ones can be added from time to time at low cost;
- Sets of wireless-networked laptops in trolleys can be shared between different classes;
- Cost of installation and the simplicity of incremental increase;
- Very low cost coverage of whole sites for small schools;
- Wireless networks and mobile computers are made for each other.

For most schools a combination of wired and wireless networks is the optimal solution: the latter extend wired networks very easily and cheaply.

**Wireless and wired together**

At present it can make good sense for most or all computers in a suite or suites to be connected through wired points. However, supplementing this with wireless means the centre of the room can be used more flexibly at lower cost than bringing wires across ceilings or floors. Supplementing a wired network that is dispersed across the school with wireless zones
means the remaining parts of the school can be included in the network more cost-effectively.

- Covering areas with wireless works well where pupils or staff are more mobile and the facilities are used in different ways from time to time (e.g., the school hall, D&T workshops or art studios). It allows for frequent rearrangement of rooms and for computers to be located temporarily in any position without undue cost or time taken.
- Wired computer suites can be used for whole-class ICT teaching and examination classes (e.g., GCSE, GCE or VCE IT or IS lessons) while ICT integrated into other subjects takes place in their respective departments on wireless.
- Existing investment in a wired network can be retained, and extended at lower cost.
- Outlying buildings, too expensive or too difficult to reach with wiring, can be brought into the network with wireless.
- Adjacent schools, such as a primary and a secondary sharing a campus, can use wired or wireless networks indoors and link with wireless across the gap between them.

Exemplar 4

Nine hundred wireless laptops in a community school

Ninestiles Community School, a mixed comprehensive of 1400+ students in Birmingham, has a site-wide wireless network that is one of the largest in Western Europe. Accompanying this is a determination that all staff and students at the school will be equipped with a computer, a goal that currently is well within sight as there are over 900 laptops in the school. Instead of converting classrooms to computing rooms, computers can now be used when and where appropriate to the needs of the particular topic. Students can use computers to research, take notes and work on projects as and when they need to. The school has given careful consideration to logistics and support issues and the significant funding requirement, and has worked closely with the Birmingham eLearning Foundation. Anyone visiting the school is immediately struck by how natural and integrated is the use of ICT in teaching and learning.

Wireless everything?

Many schools connect their main peripherals such as printers, whiteboards and LCD projectors to their wired network – but they can be connected to a wireless network that is not linked to a wired network. For printers, a wireless print server is generally needed though one school reported using colour inkjet printers to provide simple local ‘wireless’ printing via their infrared ports. In this school they found that printing speeds were acceptable and computers connected well, even from 30-40 metres away. In time, the short-range technology ‘Bluetooth’ (see chapter 7) may be the method used to link wireless-equipped laptops to whichever is their nearest printer, projector etc without any user action.

Alternatively, a single access point connected to a traditional wired network with a printer attached allows printing as if you were on a wired-in machine. But even then, the desired printer software must be installed on the relevant machine. At King Edward VII Upper School, class sets of

Short battery life and access to mains power are still major issues to consider
Laptops are set up to print to one specific printer by default. Students’ own laptops and staff laptops have the capacity to use a number of printers. If staff are covering for absent colleagues, they can install a new printer onto their list in under a minute. The students check the print queues: if their work cannot be printed in a certain room before the end of the lesson, they print to a printer where their next lesson is and collect it from there.

A number of electronic whiteboard suppliers are using graphics tablets to control their electronic whiteboards via wireless technology. Other suppliers have software for these tablets to wirelessly control a laptop and projector. This combination can provide most of the features of an electronic whiteboard without the board, hence at a much lower cost, and with the added advantage that the tablet can be passed around the class for student use. It is also possible to use more than one tablet in the same room to encourage student interaction. Examples are the Wireless Meeting Pad, with its Lynx software, from Accurate PLC (www.accurate.plc.uk/education/), and the Classpad from Research Machines (www.rm.com/). However, not all wireless tablets can be used without the electronic whiteboard.

Video conferencing, at present, can give problems on wireless networks, though these are likely to be overcome soon.

Also, it is now common to link keyboards and mice to computers without wires (using infra-red) – or even such as a headset, PDA or MP3 player (using Bluetooth technology) – but for student use, schools may prefer to keep these attached by wires! Decisions always need to rely on a pragmatic understanding of the realities of life in schools.

**Laptops or sub-laptops, handbelds or PDAs?**

Although laptops may operate under the full version of Windows or MacOS like their desktop equivalents, they have disadvantages:

- **Weight** – enough to cause strain if carried much or badly;
- **Bulk** – the computer plus power supply and a few extras like disks, along with PE kit and other school necessities, adds up to too much to carry;
- **Battery life** – about an hour and a half is realistic.

Batteries are still the critical factor in ‘anytime, anywhere’ learning. In the survey of schools that was part of the project that led to this publication, more complaints were received about the difficulty of keeping batteries charged than any other issue. Adding a wireless link (whether built in or through a PCMCIA card) can shorten battery life significantly, though some wireless cards have a software-controlled energy conservation system that keeps them in ‘doze’ mode until needed, thereby reducing battery drain.

Handheld computers of the Psion, NEC and HP Jornada type can be relied on for over five hours of use – which is effectively a full school day. These smaller-size units are also much easier to stow and carry and are accommodated better on normal school desks. Their disadvantages are fewer functions and non-standard operating systems – though some children interviewed have said they liked the latter because it made them think. While these devices are going out of production, refurbished ones are available and new products are constantly emerging. Thin client technology (see overleaf or glossary) can overcome the applications problem.
Wireless networking is not the only important new development. Lighter machines, better batteries, PDAs, and ancillary equipment – eg. charging trolleys, digital cameras and videos – are making technology exciting, useful and logistically feasible.

PDAs have the advantages and disadvantages of handhelds but each to a greater degree. Portability is their main attraction. Upbury Manor School in Gillingham, Kent, is a secondary modern school of just over 1200 pupils that has been exploring the use of PDAs. In the mathematics department the wireless network has allowed teachers using the PDAs (Compaq iPaqs) to control their electronic whiteboards. Information written on the PDA is transferred by infrared link to a PC connected via the wireless network and then through to the whiteboard, allowing the staff to move freely around the classroom. Alternatively, Palm PDAs can be used with a device called a ‘Margi’ to link to a projector direct. The smaller size and long battery life of handheld computers have distinct advantages in some situations, such as when used with digital cameras and digital video for instant capture and, perhaps, downloading to the network. A mixed economy may be the best answer.

Another option: tablet PCs

From late 2002 a new form of portable computer has been available. These look very similar to a standard laptop but they are designed for pen writing on screen rather than keyboard input. Some have a keyboard over which the screen swivels round and hinges down; others look more like an A4 pad – which is how they are intended to be used. Above all, their success will depend on how reliably handwriting is digitised, to gain all the advantages of search and replace, spelling correction etc that keyboarding allows. However, it is clear that tablets have immediate advantages for note taking (including diagrams) which for many children will be important to their learning style and some teachers are already very enthusiastic about the advantages tablet PCs bring. The other expected use of these is as e-books, for comfortable and convenient reading on screen. Suppliers of tablet PCs see education as a major market, but they have the battery life and weight disadvantages of standard laptops, so their suitability for schools will be subject to similar questions.

What data is held where?

Full-size laptops replicate desktop computers in having large hard disks which allow the user to store both applications (programs) and data files. However, it can be an advantage, especially when using smaller devices such as handheld computers or PDAs, to hold applications and even data centrally on a server using the local computer as a ‘thin client’. This allows more powerful applications to be used. Web pads operate only in this way. If the data is held in an intranet, it can be accessed using the small device from anywhere, either over the wireless network in-school or over the internet from elsewhere.

Some schools are using this approach, combining handheld computers as thin clients with school application servers, largely for the battery life and low carry weight advantages that it brings.

Critical mass – parallel developments working together

Many schools that have invested in various aspects of ICT have wondered whether it has given the value they wanted. Sometimes it seems as though...
it simply adds more (troublesome) hardware. Sometimes new applications prove over-complex to learn and exploit, so make little impact.

Mobile computing with wireless networking does not offer a magic wand. But our responding schools’ experience is that wireless local area networks, when combined with a small number of other related changes, can tip the school over a point of ‘critical mass’, releasing the potential of these changes.

Much has been made already of the complementary qualities of WLANs and mobile computers, whether full-size laptops or smaller devices. The key outcome from these two together is flexibility of network and internet access. This can release some of the key benefits set out in chapter three, especially widening access to more children. These advantages alone make the investment worthwhile and set schools on a path towards further developing ICT to respond to the demands created by improved access.

When further combined with good central file management and an effective school intranet, pupils get their own electronic work area and efficient access to information and resources.

Teachers gaining expertise with applications that fit their special interests or subject find they can spend more time furthering their skills as they can take a laptop into a supervision lesson or home for the weekend. Others on ICT training can quickly follow up lessons learnt with further practice. Internet access allows them to identify, file and retrieve the most valuable resources.

One school's assessment
The introduction of laptops using wireless technology has made a significant impact on teaching and learning at Dorrington Primary School, Birmingham, including:

**Literacy**: improved spelling, reading, creative writing, punctuation and listening skills;

**Numeracy**: number facts, plotting graphs and their interpretation, spreadsheets, shape;

**Science**: scientific knowledge using the internet, graphical representation of scientific data, monitoring change using sensing equipment, saving and using images from a microscope;

**Foundation subjects**: using the internet to understand the past and the world; producing timelines; collecting and analysing geographical data; manipulating and creating images; and understanding artists and art movements, music and musicians, faiths and cultures;

**ICT**: computing, keyboarding and reasoning skills and logical thought; photographing images and inserting into own work;

**Staff**: own computing skills and confidence; record keeping; recording pupil performance; acquiring a wealth of resources to support learning; improving pupil motivation; creating resources at home and copying these wirelessly to the server for use with classes.
Getting started

Why do you want it?

The information and evidence from other schools in this document should help schools decide that they want to install a wireless network and to know why. The critical starting point is to define the curriculum issues that it will address. For example, Carmel Technology College focused on the need it identified to improve computer access in a number of different areas where small numbers were needed. Jeff Joseph Sale Moor Technology College wanted to extend access to the surrounding community. Each need has a different solution, conditioned also by the finance available.

It is also important to focus more narrowly – to the teaching and learning changes sought, so that the other conditions for success, beyond the technology, are also tackled. Paramount among these is the training of staff, teachers and non-teachers, who will be involved in using the system. This should include consideration of their own professional use of the technology in support of their teaching. Sawtry Community College phased in wireless laptop developments; their view now is that they should have involved more teachers at an earlier stage as they could then have moved further, faster. It may not require every teacher to be equally heavily involved, but those beyond the immediate users need to understand the purposes behind the developments.

This then requires a strategy, thought through beyond the early stage to create a vision of where the innovations might lead. And like all strategies, it is likely to need revising as developments unfold.

Small-scale pilots

Many schools reported on the value of conducting a small pilot scheme, resourced with some allocated staff time, to ensure that the technology installation would be successful and to demonstrate some of the teaching and learning advantages as soon as possible. This secures an aura of success and future promise. Project champions are also needed, to sustain the scheme as it rolls out to a larger group. The timescale for this, if it is to properly inform future developments, may be longer than expected – as is usual with ICT or any significant development involving new technology and/or changing people’s attitudes and behaviour.

A typical starter scheme might be the use of a single base station or access point and some wireless cards to add to existing laptops, or the concurrent purchase of a few wireless-enabled laptops. Purchasing a mobile access point first allows you to test different areas of the school and get a picture of the likely difficulties that you might meet on expanding the network. Even having done this, it is important to get your suppliers to test the site and take responsibility for ensuring the coverage you require. Building on a successful pilot can be done in a series of stages, each involving a small set of extra access points possibly matched by increased laptop provision. Alternatively, if funds are available, a
school-wide scheme could be installed in one further large tranche.

Before the question of what geographical coverage is addressed, the limited teaching and learning purposes of the pilot should be agreed. Robin Hood Primary School decided to target a full year group (Y5) in its pilot, allowing for interaction between the pupils and teachers in developing the system.

**Suppliers, and how to buy**

The number of manufacturers of wireless hardware and suppliers with experience of installing and configuring systems has increased significantly. It is now possible to insist that your supplier has previous experience of installing wireless networks in schools. Alternatively, as interest is growing in these systems, a supplier wanting to gain experience may offer an advantageous price. There is no reason to believe that wireless networking makes demands that an experienced wired network installer cannot meet.

A site survey is crucial to establish the most cost-effective approach to start with. Insist on a thorough survey as this may reduce the number of access points through careful siting. A poor quality survey could lead to serious cost escalation as further access points prove to be needed. However, it is quite likely that you will need to add a few extra points to deal with dead spots found in daily use. Question your suppliers carefully about the advantages of the Wi-Fi standard they are proposing to meet (currently 802.11g or 802.11a), including the number of access points initially needed and any possible increase in provision over time.

Schools should expect to work with their supplier to develop their system. Only experience of the building and of patterns of use will determine exactly what is right for any one installation. Suppliers recognise the committed year-on-year ICT spend that is now established in schools, and should be keen to get the follow-through sales that a good partnership can bring. Similarly, as a regular supplier becomes trusted by a school, the benefits may outweigh slightly higher prices than may be obtained from time to time on the open market.

Using a single supplier to provide the hardware, install and maintain it over time, has distinct advantages. Although wireless equipment and supporting software can normally mix and match satisfactorily, especially if all are Wi-Fi approved, using multiple suppliers can lead to each blaming the other for any failures. By contrast, for those on a tight budget, it may be possible to save money by purchasing cards from one supplier and base stations from another and using a local installer whose reputation is established. Schools should always try to minimise the extent to which they have to worry about the technology and whether it is functioning. They have enough to consider in attempting to achieve the transformation in teaching and learning that these systems can enable. Such transformation can only be achieved if considerable, all-round effort is put in to the pedagogical and staff training aspects.

You might consider service level agreements (SLAs). These could include a statement of agreed performance characteristics, the nature of technical support provision and details such as response times and penalty clauses on the supplier. But given the ever changing nature of the technology, and the rate of growth of interest in it, a developmental partnership with your
supplier may be more beneficial. Commercial SLAs are usually of little use in the school context, and too demanding a service level agreement will rarely give value for money to a school.

Larger schools with high levels of expertise in their ICT management can reasonably expect to install a wireless system or a wireless extension to an existing network themselves. But the funding of extra time and possibly some consultancy support for the staff involved should be budgeted for.

As has been explained, wireless networks operate at a slower data transfer rate than the common wired ethernet networks, and this can be expected to continue as each technology receives further development. At this stage, though typical pupil videos or digital photos will be fine, it is not sensible to expect wireless to provide a high level of performance that will support access to major multimedia files. This should be given serious thought, especially as the DfES Curriculum Online scheme gains in scale. Many areas of a school will find wireless satisfactory, but as multimedia demands grow and external bandwidth increases, a new round of questions will arise over the suitability of wireless.

Remember, standards are constantly changing: it is never ‘the right time to buy’ as technology inexorably marches on. Schools will benefit from the fastest available Wi-Fi standard; but this may be too expensive, and will certainly cause greater drain on batteries, so reducing the flexibility of laptops.

**Implementation tips from schools**

- Small-scale pilots help identify issues and shape future use.
- Portable computing and wireless go hand in hand.
- Keep a curriculum focus – don’t get carried away with technology.
- Plan by setting up a team and see it as CPD for those involved – have a neutral chair, and include curriculum representatives and technical people. Also governors? Local business people? LEA rep?
- Make sure all staff are well informed and convinced of the value of the exercise.
- Training, training, training – technical and pedagogical.
- An Inset day to plan and practise use has been the key to success in a number of schools – with continued periodic training/development sessions.
- Consider appointing one or more laptop/wireless champions – pupils and staff.
- Good management of laptops/mobiles is critical to success.
- Poor battery management can waste the mobile resource – make sure chosen models have good battery life.
- Consider smaller, lighter machines with longer battery life.
- Consider increasing power outlet provision in key rooms.
- If pupils are to carry computers around, full-size laptops can be weighty, especially for small children or when carried long distances (home?). Look at specially designed computer backpacks.
- Storage trolleys (eg, Lapsafe) make it easy to store, charge and move laptops, but they still need time to charge.
- Even small steps can be tricky with a trolley!
Practical considerations

Quick reference lists

The following lists of considerations will be useful for those responsible for taking decisions about installing wireless networks. For sources of more technical information see Annex A.

Buildings and architecture

- New brick-built schools tend to get good coverage: eg, Denbigh School at Milton Keynes could cover its whole school with three access points.
- Older brick schools might not: eg, King Edward VII School, Melton Mowbray, has needed 80 access points, in 1900-1970s buildings.
- The poorest reception seems linked to 1960/70s reinforced concrete and/or metal frame buildings, probably because of the amount of steel in them.
- Access points often work better up and down through floors than side to side through walls.
- If there is a problem communicating through floors, at least one company is launching the technology to bridge between floors through the mains electricity wiring while continuing to use wireless on each floor.
- Dead spots – you will need to experiment, even when a formal survey has been carried out. And you may need to infill dead areas with further access points later.
- Power can be carried to access points over a school’s wired ethernet network to reduce installation costs.

Bandwidth

- As schools move more and more data around internal networks (eg, through their intranet), so too external networking, via the internet or grids for learning, will increase in usage.
- Bandwidth is measured by the maximum number of bits (amount of data or ‘traffic’) transmitted per second: megabits per second or Mbps.
- The minimum bandwidth which should be referred to as broadband is 2Mbps.
- Regional grids for learning are typically installing 2Mbps as a minimum for primary schools – from 10 to 32Mbps for secondaries. Bandwidth is subject to ‘M25 syndrome’: you soon want more than you’ve got. Typical wired internal networks run at 100Mbps.
- Externally, bandwidth is a commodity and costs money – the more you buy, the more it costs. Internally, the higher the capacity of a system, the higher the total cost (in general).
- Heavy traffic can be reduced by sensible planning of the nature and volume of use and by making adjustments such as adding access points in the light of experience.
- Multimedia (eg, streaming video) is too demanding for the early Wi-Fi standard, 802.11b, offering 11Mbps transmission.

7 See ‘Netplug Bridge: www.lanergy.com
Wireless networking in schools

• The DfES’ Curriculum Online, launched in September 2002, is increasing the number of bandwidth-heavy applications and data for schools. Ring-fenced money will be included for schools to purchase online materials, later to be provided through electronic learning credits (eLCs), is leading to an increase in the use of networked delivered learning resources.

• The BBC is expecting to produce considerable online resources for schools in time, much of which will include video and other bandwidth-heavy features.

Standards

• Interoperability is good between products from different suppliers that use the same established standard (denoted by the term ‘Wi-Fi’). That is, they generally work together reliably.

• The 802.11a standard is currently less prone to interference than either 802.11b or 802.11g, partly because there are fewer devices that are liable to be operating in this 5GHz frequency than the 2.4GHz (microwave ovens, cordless phones and Bluetooth devices all work in the 2.4GHz frequency) and partly because of the technology within the 802.11a standard itself.

• Although the 802.11a standard has a shorter range than either 802.11b or 802.11g (maximum 50m compared to approx maximum 100m), it is capable of supporting more simultaneous users. Both 802.11b and 802.11g can only support three non overlapping channels in the same range, whereas 802.11a can support up to eight. NB, 802.11a products tend to be more expensive.

• There is a step change in moving from 802.11b to later standards but the earlier products will still function and will integrate (but not interoperate) with the new to allow them to run side by side.

• There has been so much investment in the original 802.11b that it can be expected to continue to be supported – it is a widespread office/consumer technology that even when ‘out of date’ will live on – as has VHS in the video recording arena despite better systems becoming available.

• Dual-mode systems (supporting 802.11b and g for example) are available to ease integration between early and later Wi-Fi standards.

• None of the standards actually delivers the nominal bandwidth quoted, eg the nominal 54 Mbps systems (802.11a & g) generally deliver about 20Mbps

• Future usage may see a combination of standards in an institution – eg, 802.11g for students or for remote desktops with no battery reliance and 802.11b for staff making a lighter demand: eg, less use of multimedia.

Here are the three generations of wireless networking technology:

**802.11b – Wi-Fi** - The original, well-established, low cost technology. Many products available. Lowest data rate means lowest battery drain. 2Mbps originally, later (and more commonly) 11Mbps, while some manufacturers offer 22Mbps, 2.4GHz frequency band.

**802.11a** - Broader bandwidth, established later in the USA, originally only available with special licence in the UK, 54Mbps 5GHz frequency band so less prone to interference. Able to support a greater number of overlapping networks but shorter range and more rapid speed drop-off.
than 802.11b or g. Not interoperable with either 802.11b or 802.11g equipment. However, several manufacturers produce dual mode and tri-mode (a-b-g) access points, wireless LAN cards and internal chip sets which will interoperate.

802.11g – Higher data rate ‘upgrade’, is backward compatible with 802.11b equipment but actual data rate drops to about 10Mbps in the presence of 802.11b equipment, 2.4GHz frequency.

Cautions:
- Higher data rates mean greater battery drain on portables.
- The speed of the connection drops off as the signal weakens with increasing distance from an access point.
- Access points from different manufacturers should, but may not interoperate reliably – compliance with the 802.11f standard ensures they will.

Further 802.11 wireless networking standards are constantly in development, though some focus on external networking over long distances. 802.11e, when available, is expected to greatly improve multimedia delivery over wireless local area networks.

802.11h – 5GHz frequency band. Ratification expected 2004
- Has the same data rates and range as 802.11a
- Overlays 802.11a to solve both interference and overuse problems
- Improves coexistence with other devices on the same 5GHz frequency band.
- Requires devices to check whether given frequencies are in use before transmitting (dynamic frequency selection or DFS),
- Only transmits at the minimum necessary power level (transmit power control or TPC).

Other wireless technologies have varying degrees of promise for schools. Of particular interest is Bluetooth, which operates over a very short range (up to 10 metres) and in the 2.4GHz frequency band, so it may cause some interference with 802.11b and 802.11g equipment. Bluetooth was initially used for ‘personal area networks’ (PAN) eg headset wirelessly connected to mobile phones. Bluetooth has the potential to be the standard for linking peripheral devices to a PC, though it will not really compete with wireless LAN equipment as a local area network.

Other technologies include:
- Infrared (as used by television and other remote controls to ‘beam’ digital data)
- DECT (for domestic phones and data)
- Home RF
- HiperLAN2 – a European standard similar to 802.11h; its future is uncertain.

IEEE 802.3 is the established wired standard (ethernet) generally now operating at 10/100Mbps shared bandwidth.
Other issues

Health and safety

Nothing is free from risk. Information on risk analyses for radio wave dependent communications devices is still somewhat limited. Mobile telephony has been the main centre of attention; emission levels of wireless networking equipment are far lower than those of mobile phones and WLAN equipment is not held against the head. WLANs are increasingly widely used in hospitals. One manufacturer’s wireless equipment was found on testing to emit one-tenth of the levels (SAR) deemed acceptable under US Federal Communications Commission regulations. Keeping all WLAN equipment at least 30cm away from users’ heads is a sensible precaution.

Responsibility for wireless health and safety lies with the National Radiological Protection Board (www.nrpb.org). At the time of writing (summer 2003) the website does not indicate any potential dangers of wireless networking technologies.

Given our current knowledge, it is reasonable to assume that WLAN technology offers no appreciable risk to children or others in schools.

Network security

There are three important aspects to data security: how well your data is locked away when stored; how easy it is to access while being transmitted; and how easy it is to hack into the stored data.

For the first, whether you have a wired or wireless network makes no difference but this is the most important aspect. Both gaining access to data when on a network and resistance to hacking to gain access to the network depend on good data security such as password protection. Scare stories about lack of security on Wi-Fi revolved around unauthorised people gaining access to a network as a result of the nature of radio signals, which disperse in all directions. So they can be picked up by someone living nearby, or with a laptop sitting in a car near your school.

To protect against such people getting access to your data it must be encrypted as it passes around your network. This risk was greatest if no security was enabled on the network or, indeed, with the old WEP standard even when enabled. The current standard of security protection for wireless networks is the so-called ‘Wi-Fi protected access’ (WPA), which is included with the system software from all manufacturers. This replaced WEP, the widely discredited first attempt at security for wireless. Be sure to check that your supplier has enabled it.

Higher levels of security can be obtained, but these can require additional expenditure on hardware and significant increases in the level of technical expertise required. Dynamic key management, mutual authentication of users, message integrity checking and other forms of higher security are being developed. Vendors will have details as they become available on the market. You may find that your supplier will upgrade your security software at no cost as it becomes available – you should ask for this assurance.

Remember however that the greatest vulnerability for a wireless network is if a configured laptop is lost or stolen.

The lower security levels of wireless networks compared to wired ones...
has caused a stir in commercial circles, because their data and systems can be more vulnerable to outsiders. The issue for schools is more complex.

Technical staff are likely to want to keep their system as secure as possible but some educationists are recognising a potential community benefit from leaving public access - to the internet in particular - open. As wireless networks inevitably ‘spill’ beyond physical boundaries, those with suitable equipment who are within range can log on to the school’s network (subject to all the usual password etc protections) and use the internet. As schools’ internet connections are now generally ‘always on’ and unmetered, the ‘free’ use of internet access can easily be extended to the community. The Jeff Joseph Sale Moor school example in chapter 3 shows a commitment to the principle of enabling communities through ‘piggy-backing’ onto public sector networking provision.

It should be emphasised that access to data on systems that are networked wirelessly can be prevented by a range of security systems (firewalled sections, locked folders, password controls etc) exactly as for wired networks. Also, for someone to break in to a school’s wireless network would require them to obtain the necessary network access code. So, as schools recognise the critical importance of giving teachers access to administrative data (management information systems) while making curriculum materials widely available, a new issue is introduced if the networking is wireless.

Schools must be aware of their responsibilities under the Data Protection Act, to protect pupil data or any other sensitive information if transmitted around their wireless network. Any encryption technology can theoretically be breached by determined hackers using specialist tools, but this may be regarded as unlikely to be a practical problem for schools.
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access point</td>
<td>The hardware node of a wireless network that local computers connect to or through. Some hold a PC (PCMCIA) card which can be replaced to upgrade to later standards.</td>
</tr>
<tr>
<td>Always on</td>
<td>A connection (especially to the internet) that is instantly available because it is constantly connected (as opposed to dial-up).</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>The amount of data that may pass over a connection, determined by the speed at which it will pass: 2 megabits per second (basic broadband) or 56 kilobits per second (the fastest domestic modem – narrowband).</td>
</tr>
<tr>
<td>Bluetooth</td>
<td>A very short-range wireless link system particularly suitable for personal technologies such as mobile phone to headset, laptop to printer, or PDA to desktop computer; operating around 1Mbps.</td>
</tr>
<tr>
<td>Broadband</td>
<td>A faster form of connection (usually applied to the internet) commonly providing a minimum of 2Mbps, with 8Mbps widely seen as the minimum currently acceptable for secondary schools, 2Mbps for smaller primaries. Bandwidth needs can be expected to rise continually for some years.</td>
</tr>
<tr>
<td>Contention ratio</td>
<td>Sharing bandwidth between users, possibly resulting in slowing transmission; measured by the number of users sharing the given bandwidth, typically 8:1 for the number of users sharing an access point on a WLAN.</td>
</tr>
<tr>
<td>Dial-up</td>
<td>A connection through a modem or terminal adapter (ISDN) that is initiated by dialling each time it is needed and closed down again afterwards.</td>
</tr>
<tr>
<td>Encryption</td>
<td>Scrambling data so it is not readable by unauthorised users. Usually automatically interpreted for those using the correct password.</td>
</tr>
<tr>
<td>Ethernet</td>
<td>The ubiquitous set of standards for computers to communicate across networks, with varieties for wireless or wired transmission and standards of cabling.</td>
</tr>
<tr>
<td>Interoperability</td>
<td>Term describing ability of equipment from different sources to work together.</td>
</tr>
<tr>
<td>ISDN</td>
<td>Integrated Services Digital Network – a digital service run over telephone lines (dial-up) that typically offers about twice the speed or bandwidth of a modem (128Kbps) or multiples of that. Incurs a charge per minute used.</td>
</tr>
<tr>
<td>Kbps</td>
<td>Kilobits per second – a measure of the speed of data transfer or bandwidth. 1000Kbps = 1Mbps.</td>
</tr>
<tr>
<td>LAN</td>
<td>Local area network – a medium-range network connecting computers and peripherals within a building or site.</td>
</tr>
</tbody>
</table>

Schools are advised to monitor the Becta website (www.becta.org.uk) for updates to information about wireless networking.
MAN

Metropolitan area network – medium-to long-range networking available in some major cities, typically at 22+ Mbps.

Mbps

Megabits per second – a measure of the speed of data transfer or bandwidth. One Mbps = 1000 Kbps.

Network

A set of computer-related equipment linked together to allow the sharing of files, peripherals such as printers and, sometimes, applications usually operating through one or more central servers which service the needs of the others (see also ‘Peer to peer’).

PAN

Personal area network, very local linking – eg, desktop computer to PDA, (see Bluetooth).

PC card

Shorthand for a PCMCIA card.

PCI card

Fixed internal card for a desktop computer to provide additional circuitry such as to connect to a wireless network. Some act as a holder for a PCMCIA card, which can be replaced to upgrade to later standards.

PCMCIA card

Removable thick credit-card-sized plug-in for laptop computers providing extra functions such as wireless networking (also becoming available in smaller formats such as ‘compact flash’ and ‘secure digital’ for PDAs).

PDA

Personal digital assistant (type of small handheld computer).

Peer to peer

A network of linking computers, of equal status, without a server.

Router

A device, connected to at least two networks, which determines the next point to which data that reaches it should be forwarded to its destination.

Thin client

Low cost centrally managed computing device that uses applications running on a central server.

WAN

Wide area network – long range, linking between different buildings in or beyond a town, even internationally.

WEP

Wired equivalent privacy – the first and basic security protocols available on all Wi-Fi supporting software; defaults to disabled, switchable through at least two levels to a maximum of 128bit. Now replaced by WPA.

Wi-Fi

Short for ‘wireless fidelity’ - the popular name for 802.11-based technologies that have passed Wi-Fi certification testing. This includes IEEE 802.11a, 802.11b, and 802.11g technologies. Also used for equipment that contains both 802.11a and 802.11b (or 802.11a and 802.11g) technologies - commonly called ‘dual band’ or containing a/b/g technologies referred to as tri-band. Wi-Fi certification now also denotes what level of security a piece of equipment offers.

Wireless network

A network of computers and peripherals (printers etc) linked without wires, usually through radio transmission.

WLAN

Wireless local area network, normally achieved using radio transmission.

One last benefit: contractors cannot cut through a wireless network connection, as they can when digging up or chiselling through cabling!
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPA</td>
<td>Wi-Fi protected access - the later, improved form of security protection for data transmitted over WLANs, replacing WEP.</td>
</tr>
<tr>
<td>WWAN</td>
<td>Wireless wide area network – a WAN using wireless technology - radio, microwave or laser, the latter two being restricted to line of sight (search <a href="http://www.becta.org.uk">www.becta.org.uk</a> for ‘wireless wide area network’ for more information). To become increasingly common using advanced mobile phone technologies such as GPRS and 3G.</td>
</tr>
</tbody>
</table>
Sources of further information

**Becta**
The Becta advice site for teachers (www.ictadvice.org.uk) hosts a range of information on wireless technologies. This includes:

*What is a wireless local area network?*
*How to choose a wireless local area network*
*How to make the most of a wireless local area network*

More detailed information, aimed at head teachers, senior leaders and coordinators, is available from the Becta Technical Briefing Paper on wireless networks.


**Mailing list**

Becta provides a mailing list for those interested in gaining current information on a range of technical issues. To subscribe to the list, email majordomo@ngfl.gov.uk. Leave the subject line blank and in the body of the text, type: subscribe broadband. You will be sent an introductory file giving more details of the list and how it operates.

**Security**
The Wi-Fi Alliance

The Wi-Fi Alliance is a nonprofit international association formed in 1999 to certify interoperability of wireless local area network products based on IEEE 802.11 specification.

http://www.wi-fi.org/OpenSection/index.asp

**Safety**
The National Radiological Protection Board (NRPB)

Working in partnership with the Health Protection Agency, the NRPB has investigated the relationship between wireless technologies and radiation.

www.nrpb.org

**Suppliers**

Accredited service suppliers

The scheme is intended to provide schools and other ICT purchasers with a maintained list of quality assured service suppliers.

http://www.ictchoice.org.uk/

**Handheld computers**

Becta has produced a publication outlining the benefits of handheld technologies. It is based on the findings of a pilot study involving 30 schools.

http://www.becta.org.uk/research/reports/portableict.cfm
Suppliers

Apple Computer International
www.apple.com/uk/education/
0800 039 1515

Centerprise International Limited
www.centerprise.co.uk/Groups/Education/default.asp
01256 378130

CFL Computer Systems Limited
www.cfl-systems.com/home.htm
01446 775985

Chisholms Computers Limited
www.chisholms.com/education.asp
01482 601100

Computer Village
www.compvill.com/products.htm
01225 405111

Comtec Education PLC
www.e-ducating.com/
01225 446122

CSE Education Systems
www.cse-net.co.uk
01993 708775

Egton Consulting & Technical
www.egton.net/
08701 215 215

Electronic Frontier Limited
www.elecfron.com/
0118 9810600

Elongex PLC
www.elongex.co.uk/
020 8452 4444

Epic Computers Limited
www.epicpc.co.uk
01892 654444

Ergo Computing UK Limited
www.ergo.co.uk/
0115 9144144

Evesham Technology Limited
www.evesham.com
0870 160 9100
Fujitsu Services Limited
www.uk.fujitsu.com/
0870 242 7998

Gaia Technologies PLC
www.gaia-tech.com/mainsite/
01248 352459

Holdens Computer Services Limited
www.holdens-computers.co.uk/
01704 515100

Mertec Computers PLC
www.mertec.co.uk/company.htm
01792 534500

RM PLC
www.rm.com/
08709 200200

Stone Computers
www.stonecomputers.com/
01785 812100

Teksys Limited
www.teksys.co.uk/education
01562 515366

Time Computers Limited
www.timecomputers.com/
0870 830 3116

Viglen Limited
www.viglen.co.uk/
020 8758 7027

XMA Limited
www.xma.co.uk/
0115 8464000
Annex C

Wireless networking in schools

Schools consulted

Alexandra Infants School, Kent
Ashfield Comprehensive School, Nottinghamshire
Babington Community College, Leicestershire
Blessed Robert Johnson College, Shropshire
Carmel RC Technology College, Northumbria
Caroline Haslett Combined First & Middle School, Buckinghamshire
Castle Donington Community College, Derbyshire
Denbigh School, Buckinghamshire
Djanogly City Technology College, Nottinghamshire
Dorrington Primary School, Birmingham
Goffs School, Hertfordshire
Gosforth High School, Tyne and Wear
Great Ormond Street Children’s Hospital, London
Green Park Combined First & Middle School, Buckinghamshire
Highcliffe School, Dorset
Hundred of Hoo Comprehensive School, Kent
Huntington School, North Yorkshire
Jeff Joseph Sale Moor Technology College, Cheshire
Kearsley West Primary School, Bolton
King Edward First School, Nottinghamshire
King Edward VII School, Leicestershire
Lipson Community College, Devon
Meadow Wood Primary School, Watford
Ninestiles Community School, Birmingham
Parrs Wood High School, Lancashire
Pinderfields & Pontefract Hospital School, West Yorkshire
Potter’s Green Primary School, Coventry
Redhill Community Junior School, West Yorkshire
Robin Hood Primary School, Birmingham
Rodborough Comprehensive School, Surrey
Sandwich Junior School, Kent
Sandwich Technology College, Kent
Sawtry Community College, Cambridgeshire
Sir Robert Hitcham’s Primary School, Suffolk
Sir Thomas Mills High School, Suffolk
South Bromsgrove High School, Worcestershire
St Andrew’s First School, Worcestershire
St Garden Primary School, Bath
St John’s CE Primary School, Kent
St Mary’s Primary School, Dorset
St Peter’s Smithhills Dean Church of England Primary, Bolton
St Wilfrid’s CofE High School and Technology College, Lancashire
Stratton Upper Community School, Bedfordshire
The Cornwallis School, Kent
The English Martyrs School, London
The Leas Infant School, N E Lincolnshire
Tile Hill Wood School, Coventry
Upbury Manor School, Kent
Vandyke Upper Community College, Bedfordshire
Westfield Primary School, York
Whitchurch Middle School, Middlesex
Wilmslow High School, Cheshire
Worth Primary School, Kent
Yewlands School, South Yorkshire
Recent titles from the Specialist Schools Trust

**Educational outcomes and value added by specialist schools 2002**

**Making the KS3 strategy work**
A Specialist Schools perspective

**World class education**
A challenge for every school

**Wireless networking in schools**
A decision making guide for school leaders

**Musicians in schools**
A productive mix

**Best practice in Arts Colleges**
A guide to school improvement

**Best practice in Language Colleges**
A guide to school improvement

**Best practice in Sports Colleges**
A guide to school improvement

**Best practice in Technology Colleges**
A guide to school improvement

**Seeking sponsorship**
A guide for schools

A full list of Specialist Schools Trust publications is available from the address below.