The Wireless Office: Understanding the Technology Options

The wireless office is becoming an increasingly affordable reality, however users are faced with a bewildering array of products and technologies. Digital cordless telephony in the guise of the pan-European DECT standard has brought cordless voice and ISDN into the mainstream business market, but increasingly wireless users are demanding bandwidth comparable to that obtained form their hard wired Ethernet networks. To meet this demand there is now an increasingly wide choice of wireless networking equipment on the market.

In this article John Burns, of radio spectrum management specialists Ægis Systems Ltd, reviews the technologies currently available and how these fit with the needs cost constraints of potential users. The review also considers some of the latest developments in high speed, high performance radio LANs and, at the other end of the scale, the low cost “home networking” solutions that are appearing in the market.

Ægis Systems Ltd are specialists in the field of radio spectrum management and engineering. The Company provides advice and consultancy services to Industry and Government on radio spectrum matters, including system co-existence, interference mitigation and considers how the best use can be made of this increasingly congested natural resource. Further information on how Ægis can help you make the most of the opportunities radio spectrum has to offer, visit the Company’s web site at www.aegis-systems.co.uk.

Introduction

Once largely the domain of niche users in retail and warehouse environments, wireless networking is now firmly breaking into the mainstream business and consumer markets. Whilst recent high profile industry initiatives such as *Bluetooth* promise ubiquitous wireless connectivity in the future, there is already an unprecedented choice of wireless products on the market. These range from straightforward cordless telephones and PBXs to complete radio local area networks (RLANs) offering performance approaching that of their hard-wired counterparts.

The diagram below shows the main technologies currently available for wireless networking applications and how these are likely to fit into the market.

History

Wireless LAN devices first appeared in the early 1990s, serving applications where mobility, rather than speed of data throughput or capacity, was the overriding requirement. Devices such as remote bar code readers and wireless personal digital assistants (PDAs) continue to be used extensively in fields such as retail, health care and education.

A major facilitator in the growth of this market was the availability of substantial blocks of radio spectrum in bands formerly reserved for Industrial Scientific and Medical (ISM) equipment and microwave ovens. By using interference-resistant *spread spectrum* techniques (see inset), devices were able to co-exist without the need for cumbersome frequency planning or the need for regulators to identify exclusive frequency bands.

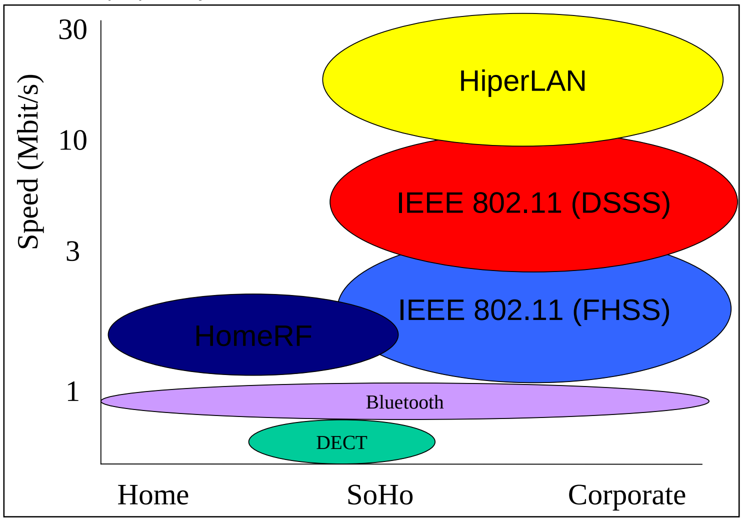
A common standard

Early RLAN devices were based on proprietary standards, locking users in to specific suppliers or technologies. This led to pressure for development of a common interoperability standard in line with the universally adopted Ethernet standards for wired LANs.

This challenge was taken up in 1990 by the internationally recognised standards body that deals with LAN interoperability, IEEE 802. Working Group 802.11 was created with a brief to develop global interoperability standards for spread spectrum wireless LANs operating in the unlicensed 2.4GHz ISM band. A 2 Mbit/s interoperability standard was published several years ago and the group turned its attention to growing market demands for even higher wireless connectivity speeds. This work culminated in the recent adoption of a global interoperability standard for 11 Mbit/s radio LANs based on direct sequence spread spectrum (DSSS).

802.11 provides a basis for different vendors’ equipment to interoperate and, as a de facto global interoperability standard has led to a marked increase in the take up of wireless LAN systems for a broad range of applications. The standard effectively provides wireless Ethernet functionality and incorporates “collision avoidance” protocols to minimise the impact of interference between co-located networks.

In parallel with the IEEE development, the European Telecommunications Standards



Institute (ETSI) introduced its own generic type approval standard for wireless data equipment, ETS 300 328. This standard specified minimum requirements for RF emissions, to facilitate co-existence between different types of system.

The entire 2400 – 2483.5 MHz ISM band is available in the UK for unlicensed operation of private RLAN systems based on ETS 300 328. Subject to certain restrictions in individual countries, this band is available on a global basis for wireless networking products.

The Present

So what does all this mean to the potential user? Whilst there are now more wireless networking products to choose from than ever before, many of those who might benefit are understandably hesitant to invest, given the pace of development and the imminence of new technologies and products aimed at the corporate small business and consumer market. Whether the user is best advised to buy now or wait will depend largely upon what the user requires in terms of speed and capacity. 802.11 interoperability provides reassurance that a future upgrade path will be available, including in some cases compatibility with next generation products such as HiperLAN (see below).

Professional RLAN equipment based on 802.11 is now readily available from a range of vendors, including Breezecom, Proxim and Lucent subsidiary Wavelan. Some suppliers specialise in particular applications, for example Telxcon is a major supplier of hand held terminals for the retail and warehousing markets.

A typical office set up, linking six PCs, a printer and a scanner via a common access point, is shown below. The typical indoor range in such a scenario is 50 – 100 metres.

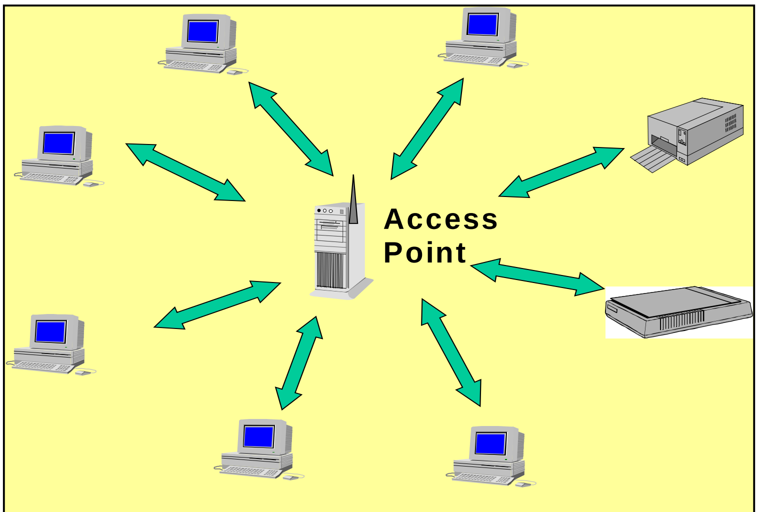
For smaller users with more modest requirements, the emerging *Bluetooth* standard and recently launched home networking devices (see below) may provide a more cost-effective solution. For those who need mobility but have limited data requirements, DECT may continue to provide the most immediate and cost effective solution.

The table at the foot of this article compares the performance, relative cost and availability of currently available and emerging RLAN technologies

LANs or PANs?

LANs as defined by 802.11 or HiperLAN (see below) are intended to cover entire offices or buildings and to provide full networking functionality. Many users may not require this level of functionality but merely wish to connect seamlessly their IT and telecom equipment. This has prompted work on a new generation of wireless connectivity technology, known as *Wireless Personal Area Networks*, or WPANs, with an emphasis on reduced cost, size and power consumption.

The WPAN concept is being developed in another IEEE working group, 802.15. However, the major drive towards WPAN products has come from *Bluetooth*, a global standard that looks set to displace most cable and infra-red connections over the next five years.



Typical Wireless LAN configuration

Bluetooth

Bluetooth is a wireless connectivity standard being developed by a heavyweight consortium of IT and telecommunications companies including Ericsson, Motorola, Nokia, IBM and Intel. Eighteen months after its formation, the Special Interest Group (SIG) behind the Bluetooth standard has over 1000 members worldwide, including all the major suppliers of 2.4 GHz RLANs and major league mobile players Nokia, Ericsson and Motorola.

Bluetooth is intended to replace the plethora of proprietary cable links that currently connect IT and telecom devices to one another and replace them with a single universal short range radio link. Unlike existing infra-red wireless links, Bluetooth does not require a clear line of sight path between the two devices and would for example, allow an e-mail to be sent from a laptop PC via a mobile phone, which might be in the user's jacket pocket or briefcase. All that would be necessary is for the two devices to be within the Bluetooth transmission range, which should be around 10 metres for most applications.

Bluetooth uses frequency hopping spread spectrum to ensure robust performance in a noisy radio environment. Both voice and data can be supported, up to a gross data rate of 1 Mbit/s. Up to eight devices or three voice channels may be connected simultaneously to form a "piconet" using a single frequency hopping sequence. Up to ten such piconets in turn may be interconnected using different hop sequences.
The Bluetooth air interface is compliant with international standards, including ETS 300 328, but in general will operate at a lower power level of 1 mW EIRP (although the standard allows for variants up to 100 mW). Whilst it is not intended to provide full LAN functionality, Bluetooth may well fulfil the needs of many users for a simple, low cost wireless connection between computers, peripherals and telephones.

According to Ericsson, by 2002 Bluetooth will be a built-in feature in more than 100 million mobile phones, and millions of PC's, laptops, PDAs and other electronic devices.

Home Networking

At around the same time as work commenced on Bluetooth, another industry consortium emerged, calling itself the "HomeRF Working Group".

This group's aim was to develop a global "shared wireless access protocol" (SWAP) for interconnecting IT and telecommunications equipment in the home. Clearly such a tool could also prove attractive in business and commercial environments where cost effective wireless networking was required. Many of the 96 members of the HomeRF consortium are also active players in the Bluetooth SIG.

Like Bluetooth, HomeRF uses 2.4 GHz FHSS technology and is compliant with ETS 300 328. It is also compatible with 802.11 and despite its name may well provide a cost effective networking solution for small office environments.

The first HomeRF products are expected to be released by the end of 1999. These will include integrated wireless networking products for shared high-speed Internet access in the home or small office from companies such as Motorola and established 802.11 RLAN supplier Proxim. A further attraction of the HomeRF standard is that the protocol is compatible with the DECT cordless phone standard, allowing seamless integration of voice and data services. SWAP can support up to 127 devices and 6 full duplex conversations per network A 48-bit network ID code enables concurrent operation of multiple co-located networks.

Meanwhile other low cost wireless networking options have emerged, based on proprietary 2.4 GHz FHSS protocols. HomeCast, developed by California based Alation, is already available commercially as the Diamond Multimedia "Homefree" product range. Aimed at the domestic consumer market, Homefree provides basic connectivity between PCs, modems, printers and other accessories for under £100 per terminal. Both Alation and Diamond are members of the HomeRF consortium and it seems likely that this will become the de facto standard for low cost wireless networking for the SoHo market.

Webgear, also based in California, have developed a range of wireless products called Aviator, aimed primarily at the small office user. A wireless LAN pack for linking up to 8 PCs or peripherals is available for self installation at a price of US$1140.

Wired vs Wireless

So how does the performance of these wireless networking technologies compare with a conventional hard wired solution? A professionally installed Ethernet system, using high performance cabling, can deliver up to 100 Mbit/s and is likely to have the edge over radio in sheer data throughput terms for the foreseeable future.

Low cost wired alternatives make use of existing telephone wiring and offer data rates of around 1 Mbit/s, comparable to the low cost home networking devices described above. Improvements are being made and companies such as 3Com and Cisco plan to have products capable of up to 10 Mbit/s throughput. However at these sort of data rates, radio interference can become a problem and wiring may need to be modified accordingly. Mains power lines have also been cited as a viable medium for indoor data transmission, but again interference becomes a limiting factor at high speeds.

However for many users the installation of a completely new cabling infrastructure is not a viable option, and the benefits wireless offers in terms of mobility and ease of configuration often more than outweigh speed considerations

The Next Generation?

Attractive as the current generation of RLAN and wireless connectivity products are, the industry continues to press forward in the quest for ever greater bandwidth.

Standards for the next generation of RLANs, known as *HiperLAN* (**Hi**gh **Per**formance **LAN**) are already at an advanced stage of development in ETSI but, as in the early days of 2.4 GHz systems there is more than one approach being pursued. The original HiperLAN 1 standard was developed by ETSI over the period 1991 – 1996. It operates at a higher frequency than the current generation of RLANs, in the 5.15 to 5.25 GHz frequency band.

Like existing 802.11 RLANs,

HiperLAN 1 provides wireless Ethernet functionality. However, the maximum over the air data rate is increased to 23.5 Mbit/s, providing useable data rates of up to 18 Mbit/s at ranges (indoors) of up to 50 metres, with guaranteed quality of service criteria for multimedia applications.

Proxim has already announced its intention to launch a HiperLAN product range, called RangeLAN5, to complement its existing 2.4 GHz RangeLAN2 series. RangeLAN5 is planned for commercial launch in early 2000,at prices comparable to existing 2.4 GHz kit.

Meanwhile work is underway in ETSI on a new *HiperLAN2* standards, which is intended to provide short range broadband wireless access to IP, ATM and 3rd generation mobile networks.

In order to limit the potential interference with satellite systems operating in the same radio spectrum, the transmitter power of a HiperLAN will shortly be reduced from its current 1W (in Europe) to 200mW in the parts of the band used also by the satellite systems. However, there are also proposals to make more of the 5GHz spectrum available for HiperLANs in the future. This could lead to the availability of a substantial worldwide spectrum allocation for high performance radio LANs.

Proprietary types of RLAN may also be permitted at 5 GHz, depending on the outcome of a consultation recently launched by the Radiocommunications

Agency. Such a move would bring Europe into line with the USA, where parts of the 5 GHz band are available on a simple RF co-existence basis.

HiperLAN is unlikely however to be the last word in RLAN performance. Researchers at Eindhoven University have recently demonstrated an over the air bit rate of over 200 MBit/s, using state of the art technology and abundant spectrum in the 60 GHz band. The range is only 8 metres but the capacity available at 60 GHz could eventually make cable redundant for high density indoor networks.

DECT

Finally, it is worth remembering that the humble cordless phone can deliver more than just voice communication. DECT's TDMA structure allows each RF channel to carry full duplex data at up to 552 kbit/s, supporting fax, e-mail, Internet, X25 and many other services. The future of DECT as a multimedia standard seems assured with its adoption by the ITU as part of the family of standards for third generation mobile and its integration with the HomeRF networking protocol.

Technology	Speed	Coverage	Price	Availability
802.11 (FHSS)	up to 3 Mbit/s	Up to 100 m	££	Now
802.11 (DSSS)	up to 11 Mbit/s	Up to 100 m	££	Now
DECT	up to 550 kbit/s	Up to 100 m	£	Now
Bluetooth	up to 1 Mbit/s	Up to 10 m	£	2000
Home Networking	up to 2 Mbit/s	Up to 100 m	£/££	Now
HiperLAN 1	up to 20 Mbit/s	Up to 50 m	££/£££	2000
HiperLAN 2	up to 25 Mbit/s	Up to 100 m	££/£££	2002
60 GHz	up to 200 Mbit/s?	Up to 10m?	£££?	?

Comparison of Wireless Networking Technologies

Further Information

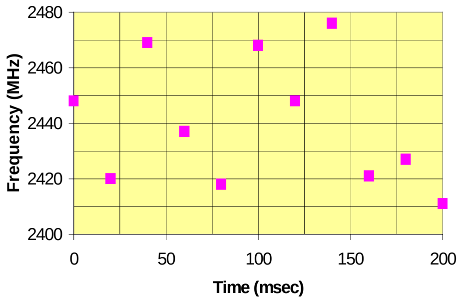
For further information on the above technology options, readers are directed to the following web sites:
IEEE 802.11: Wireless LAN Association, http://www.wlana.com/
HiperLAN: HiperLAN Alliance, http://www.hiperlan.com/
Bluetooth: http://www.bluetooth.com/
Home Networking: www.homerf.org; www.webgear.com; www.alation.com
DECT: DECT Forum, http://www.dect.ch/
Radiocommunications Agency: http://www.radio.gov.uk/

Spreading the spectrum

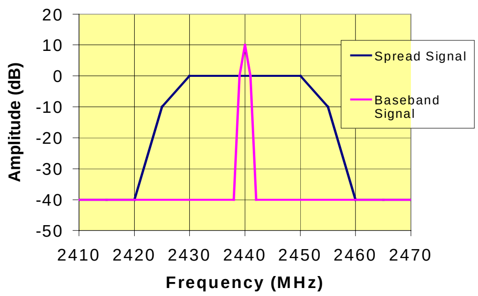
The key enabler of unlicensed wireless data systems is spread spectrum. As the name implies, this involves spreading the wanted information signal over a much wider RF bandwidth than would be required using conventional narrow band modulation techniques. Spreading the signal reduces its susceptibility to other narrow band interference signals as well as reducing the effect of the transmission on other users. The technique is thus well suited for operation in an unlicensed frequency band where many different types of device are required to co-exist.

There are two distinct approaches to spread spectrum, called *frequency hopping* (FHSS) and *direct sequence* (DSSS). In FHSS, the spreading code is used to control a frequency agile local oscillator, the output of which is used to upconvert the modulated IF carrier to the 2.4 GHz band. The resulting RF output is referred to as a *hopping sequence*. A replica of the spreading code is applied at the receiver to recover the wanted information signal. Other FHSS transmissions with different hopping sequences are rejected by the narrow band IF filter, along with any wide band signal or noise content. DSSS involves multiplying the baseband data signal by a wider bandwidth signal, which takes the form of a pseudorandom binary code.

Both FHSS and DSSS are covered by the IEEE 802.11 and ETSI standards and are used in commercially available products. FHSS is generally regarded as more resilient in a hostile interference environment, because of signal can hop around the entire 80 MHz band. However, bandwidth is limited since each individual hopping channel is only 1 MHz wide. DSSS uses much wider RF channels (22 MHz) and can thus deliver greater bandwidths, up to 11 Mbit/s using current technology. The down side is that each DSSS system requires a discrete RF channel, hence only three systems can be co-located in the same coverage area, whilst up to 22 FHSS systems may be co-located.



Frequency Hopping Spread Spectrum



Direct Sequence Spread Spectrum