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ODTR BRIEFING NOTE SERIES

Wireless Local Area Networks

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Foreword

This paper is the third to be released in the ODTR's briefing note series[1]. These briefing notes, which are issued as part of our 'Forward-looking Programme', primarily deal with technology developments in the telecommunications sector.

This briefing note is about wireless local area networks (WLANs). WLAN technology is developing rapidly and is already having a significant market impact, in Ireland and elsewhere. The main application of WLANs is in the provision of broadband data transfer within buildings, including offices, hotels, shops and homes. For example, WLANs enable laptop computers to be connected to communications networks, without being constrained by cables and fixed access points. It is envisaged that new high speed applications (e.g. for people who need to work while travelling) will develop that harness the broadband access afforded by WLAN technology.

WLAN technology is also being used externally, over longer distances, extending the reach of local area networks. This application is useful for interconnecting LANs in different buildings (e.g. on a university campus) and as a way of providing broadband Internet access to residential users. In some cases WLAN technology can be used by telecommunications operators as an alternative way of delivering broadband services.

Alongside 3G and other new and developing technologies, WLANs look set to make a significant contribution to broadband applications and access in Ireland. In issuing this paper, it is my intention to encourage potential users to examine whether WLAN technology may meet their needs, and to help stimulate wider choice of communication technologies and services in Ireland.

Etain Doyle.
Director of Telecommunications Regulation.

[1] See ODTR Documents 01/59, 'Technology Developments in Telecommunications' and 01/88, 'Next Generation Networks'.

Contents

Comments on this Briefing Note

We welcome any comments or views on this Briefing Note, and these should be sent to:

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to arrive on or before 5.30pm on Friday March 8th, 2002.

In submitting comments, respondents are requested to reference the relevant section of this document. Responses will be available for inspection by the public on request. Where elements of any response are deemed confidential, these should be clearly identified and placed in a separate annex to the main document.

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Wireless Local Area Networks

1. Introduction

There is increasing market interest in wireless local area networks (WLANs), (sometimes referred to as Wi-Fi, RadioLAN, 802.11, and Hiperlan). They are being installed in public places such as coffee shops and hotel foyers for Internet access. They enable, for example, someone with a laptop or palm device to access e-mail and the Internet at these locations simply by being registered with a service provider. This could be a specialist WLAN service provider[2] in partnership with the building operator. Alternatively it could be a hotel or restaurant chain, which wishes to provide its customers with Internet connectivity, thereby widening its range of services. In addition to the installations in public places, there are growing numbers of WLAN systems being installed in offices, shops and homes.

While a WLAN permits a limited degree of portability for the laptop or palmtop user, it is essentially an in-building wireless application for high speed (or broadband) access rather than a mobile technology[3]. Base stations typically have an in-building range of between 100 and 300 metres.

[2] In the US, companies such as Wayport (membership or credit card use - US$5 for 24 hours, or $50 monthly unlimited access) and MobileStar are rolling out networks in a number of locations.
[3] However, WLANs are being used in certain mobile applications (e.g. telemetry links to racing cars).

2. Applications

There are two main applications of WLAN technology: internal office or home LAN networking, and external WLANs used to provide broadband access in point to multi-point and point to point configurations.

2.1 Internal WLANs

An internal[4] WLAN simply requires a user to have a small WLAN card attached to their PC, enabling it to communicate with the WLAN network. Network coverage is provided from a base station called an Access Point (see Figure 1).

Capacity at an access point is shared and as more users are added the available capacity for each user is reduced. More access points can be added to help alleviate this problem, but this process is ultimately limited by the amount of spectrum available to WLANs and by the 'backhaul' capacity to the network.

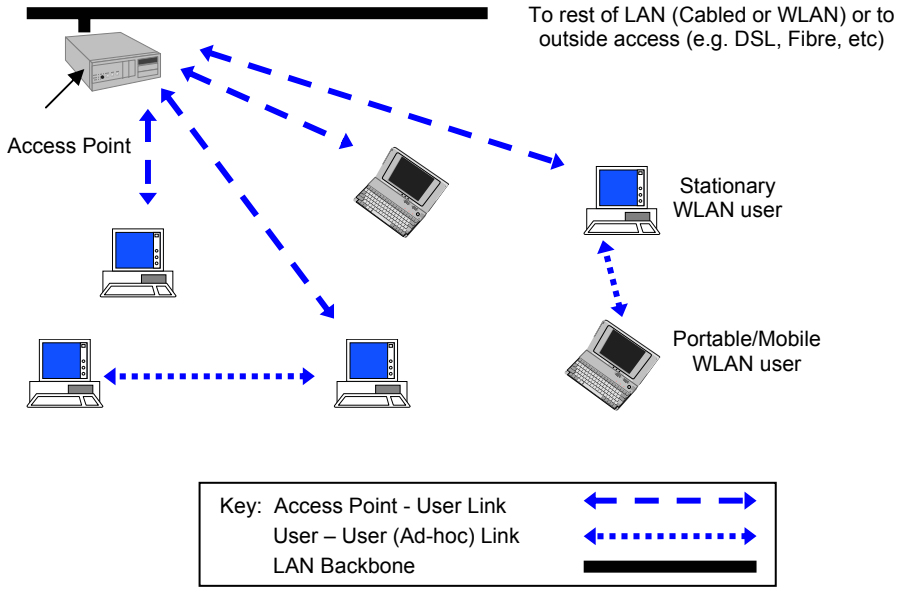

Figure 1. Internal WLAN

[4] This type of LAN is generally not restricted to indoor use although there are specific constraints on the use of these devices in the 5GHz bands (ERC Decision (99)23). However the range is limited to between 100 and 300 metres in this configuration (at 2.4GHz).

2.1.1 *Office Based Networks and Retail Users*

WLAN technology was originally developed as a wireless replacement of wired local area networks such as those that exist in offices and colleges[5]. An advantage of using this wireless technology is that users are not constrained by the availability or location of cable sockets. WLANs can be of particular use in protected buildings where cable installation may not be permitted. WLAN technology is also being used to interconnect point of sale devices in shops.

2.1.2 *Residential Users*

WLAN technology can be implemented in the home to provide a Home Area Network (HAN). Such a network allows several computers to be linked and to share resources such as printers, scanners and an Internet connection without the need to install a cable system throughout the home. Such a WLAN would also allow users the freedom to move to any location in the house (and garden) without interrupting the service. Applications are also being developed to transmit video around home area networks. Such use is likely to lead to further demand for residential broadband access to connect WLANs to the public networks.

2.2 External WLANs[6]

External WLANs consist of similar equipment to internal WLANs, but have an external antenna that the user must install so as to obtain a line of sight connection to their access point (e.g. on a rooftop, see Figure 2). These networks can typically consist of numerous WLAN links connecting multiple users to an access point (i.e. point to multi-point operation) and connecting single users to an access point (i.e. point to point operation). It should be noted that adding external antennas can potentially cause the power limits for licence exempt operation to be exceeded (see Section 5.6). Users must therefore be careful to ensure that these power limits are not breached.

Typically, external WLAN users would also install internal WLAN systems to distribute the signals throughout their homes or offices. As with internal use, available data rates will drop as more users are added to a single access point in an external scenario. Maximum data rates per user can be controlled by network management systems.

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[5] Various Irish universities have already implemented, or are currently testing, WLANs (e.g. Dublin City University (DCU), University College Dublin (UCD) and National University of Ireland Galway (NUI Galway), among others).

[6] External WLANs, operating over longer distances can also be considered as Metropolitan Area Networks (MAN) or even Wide Area Networks (WANs).

2.2.1 *Residential Users*

WLANs offer a means of low-cost broadband access for residential users. This may be particularly important in rural areas where alternative broadband access may not be readily available. Typically, WLAN technology is used by residential users for Internet access, connected to other telecommunications networks (e.g. via an Internet Service Provider).

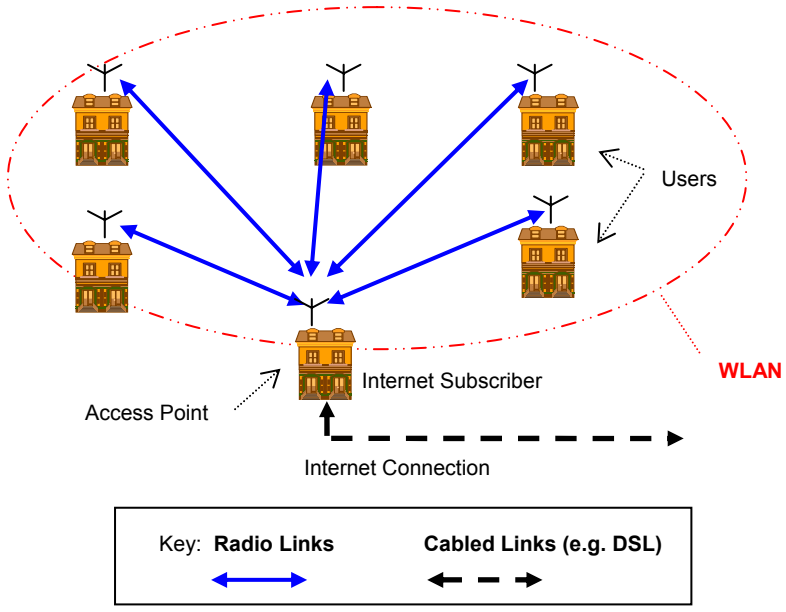

Figure 2. External network using WLAN technology.

2.2.2 *Community Based Networks*

In other countries[7], individuals or organisations have in some cases joined together to provide themselves with communications using WLAN technology. This involves building 'community-based networks' whereby members own and share the costs of their own local infrastructure and provide themselves with broadband telecommunications access and services on a non-commercial basis. A community which forms to share telecommunications services can consist of various types of people ranging from individual residential users seeking high speed Internet access, to local governments

[7] See for example www.nycwireless.net and www.seattlewireless.net . In the UK there is a wireless network connecting 11 schools and colleges in the Lancaster area: www.ednet.lancs.ac.uk .

wishing to provide communications links between their offices. The idea of setting up community based networks in Ireland is currently being explored[8].

Community based networking may in some instances provide a cost effective way of delivering broadband access services to areas that may not otherwise be able to receive them, and therefore assist in broadband rollout. Under the ODTR licensing regime community based network operators would need to have an appropriate telecommunications service licence if offering services to the public, (see also Section 5.3). We would therefore encourage prospective operators of community based networks to consult the licensing guidelines on our web site (www.odtr.ie/docs/ODTR9844R).

2.3 Other Applications

2.3.1 *Point to point LAN bridging.*

A common application of WLAN technology is to interconnect LAN segments in separate buildings on the same campus, without the need to install cables. In this configuration the WLAN system operates as a point to point link, bridging together different LAN segments. WLANs are often used for these applications on university and hospital campuses.

2.3.2 *Vehicle Area Networks*

An emerging application for WLANs is to use the technology via or in conjunction with other cellular mobile technologies such as GSM, GPRS or 3G. In this case a dedicated high performance mobile terminal (e.g. GPRS) is fitted to a vehicle, such as an ambulance, police or auto-repair vehicle. This mobile terminal is then connected to a WLAN system that will enable users to receive data on laptop computers typically up to 100m from their vehicle via the WLAN and mobile networks.

[8] See for example www.irishwan.org

3. Market Development

3.1 Irish Implications

In Ireland, WLAN technology is initially having greatest impact on internal LANs. WLAN technology was designed primarily for this purpose and is therefore best suited to it. This allows office and home workers to move about and work more freely within their premises while still using high capacity applications. The implementation of WLAN 'hot-spots' (e.g. hotels and coffee shops) should facilitate mobile data users (e.g. via laptop computers or handheld devices), which will be helpful to business visitors to Ireland. New high capacity applications designed for users of portable devices may also emerge taking advantage of the capacity available on WLAN networks.

Aside from the internal applications such as intra office and home communication networks the use of WLAN technology could have a positive effect on the broadband access market in Ireland. This technology can provide relatively inexpensive broadband access to users who for a number of reasons may not be served at present. Furthermore, WLAN technology can bring about various social benefits, particularly in the field of education and healthcare resources.

3.2 Availability of Equipment

Currently IEEE 802.11b equipment is widely available and a large proportion of laptops are now being shipped with 802.11b capability as a standard feature. 802.11a equipment is also coming on the market and more products are expected in this first quarter of 2002. The future availability of Hiperlan2 equipment seems likely to be influenced by the efforts to achieve interoperability and harmonisation of 5GHz WLAN standards, (see Section 5.5.2).

3.3 Price

Currently 802.11b PC cards (radio transmitter and receiver devices that plug into a PC) currently retail for approximately €120. Access Points (WLAN base stations) typically cost between €200 and €650. User equipment for broadband access use can cost around €500 in total, including the external antenna needed. 802.11a technology is only just coming onto the market so current prices (approximately 30-40% higher than 802.11b) are unlikely to be a good indicator of future prices.

3.4 Popularity

Deployment of WLAN networks is increasing. Use of internal office WLANs is growing quickly in Ireland and elsewhere[9]. External WLAN systems currently are less common, although some systems have been deployed already and there appears to be growing interest in providing these types of networks using licence exempt spectrum. In part, this interest is being stimulated in some areas in Ireland and elsewhere by the unavailability of broadband access by other means.

3.5 Billing and Network Access

Currently, public WLAN services operating in 'hot-spots' enable subscribers to a particular network to 'log-on' using a personal user name and password. Subscriber billing can then be implemented as pre-paid or post-paid on a per-use or flat rate basis. How this is done varies, depending on the service provider and the available options. Non-registered users can often freely access WLANs to avail of a network's local on-line facilities (e.g. train departure times, details of local hotels, and car rental services in a train station or local information in a hotel lobby). However, users would have to register, and arrange payment (e.g. on-line credit card) if they wished to gain access outside of the LAN (i.e. to the Internet) and to the user's home network.

WLANs may in some cases develop in conjunction with public mobile networks, allowing users to roam on other service providers' networks without having to register individually with each WLAN operator encountered. This could involve the use of existing public mobile authentication and billing systems (i.e. requiring WLAN user equipment to incorporate SIM[10] cards or similar technologies).

3.6 Security and Reliability

Concerns have recently been expressed about the security of WLAN technology. Many of the security flaws reported to date appear to be due to failures to activate in-built security settings, rather than inherent problems with the technology. However WLANs and some of their uses are relatively new and, in common with new technologies in general, 'teething problems' may be encountered. So increasing use of WLANs could conceivably lead to new security issues being identified. Users with high security

[9] See for example "Wireless LAN market exceeds expectations" A McLindon, ElectricNews.net, January 09 2002
[10] SIM –Subscriber Identity Module: computer chip used in public mobile handsets to identify and authenticate users.

requirements can, if they wish, implement standard virtual private networks and firewalls to prevent security breaches.

WLAN technology is developing quickly, including in terms of its reliability. In some external applications there have been reports of rain disrupting transmissions. However, it would appear that by careful engineering, including operating well within design limits, many such problems can be avoided or minimised.

4 Interaction with other Technologies

4.1 The Internet

In terms of broadband access, WLANs are mostly used for Internet access. These systems are well suited to packet based transmission that is required for such access.

4.2 Bluetooth

Bluetooth, sometimes considered a competitor of WLAN, is now expected to emerge as a complementary technology. Operating alongside WLAN in the 2.4GHz band, Bluetooth applications will typically interconnect devices at lower data rates to WLAN communicating devices (i.e. less than 1Mbit/s). However, there are concerns that these technologies will interfere with one another, particularly if they are located less than 3 metres apart. There have been suggestions that the power limits applying to WLANs in the 2.4 GHz band should be increased. However, increases in power in this band for WLANs would increase the probability of interference with Bluetooth.

4.3 3G

WLAN technology is currently unable to provide efficient high quality voice services, so in many situations 3G and WLAN will be complementary technologies, possibly integrated in the same devices. 3G operators may wish to provide complementary WLAN services for those users who at times require greater data carrying capacity rather than full mobility. Also, WLAN operators may lease capacity on mobile network operators' back haul networks to speed rollout.

5 Spectrum and Standards

5.1 Spectrum Management Environment

The majority of radio devices operate on radio frequencies that are shared with other devices and applications. In very general terms, this shared use is achieved either by detailed spectrum management, i.e. where emission characteristics (powers, frequencies etc.) are subject to detailed technical analysis of the services and co-ordination between the services and between neighbouring countries. On the other hand, relatively low power devices can often operate without detailed planning. However users of these devices must generally accept the possibility of interference and must not cause undue interference to users of other services.

5.2 The Use of Licence Exempt Spectrum

License exempt spectrum is used for what have been termed “Short Range Devices” and covers radio transmitters that provide either uni-directional or bi-directional communication, have standardised technical parameters and which have low capability of causing interference to other radio equipment.

Prospective users of short-range devices should note that:

- Short-range devices in general operate in shared bands and are not permitted to cause harmful interference to other licensed radio services.
- In general, short-range devices cannot claim protection from other radio services.
- Due to the increasing interest in the use of short-range devices for a growing number of applications, it is necessary to harmonise frequencies and regulations for these devices in Europe.

Anyone wishing to propose systems which appear to operate outside current guidelines is invited to contact the Office so we may consider these proposals in further detail. It should also be noted that temporary licences may be granted for testing and developing new systems (see www.odtr.ie/docs/odtr9915.doc). n.b. Such licences do not permit these systems to be used commercially.

5.3 European Regulation and Licensing

The CEPT/ECC[11] (formerly ERC) maintains a Recommendation[12] relating to the use of short range devices (SRDs), including WLANs in both the 2.4 and 5GHz bands, which are generally adhered to in Europe. The objective of the Recommendation is to facilitate the harmonisation of frequency usage and an open market in SRD technologies. This ECC Recommendation specifies a 100mW power limit in the 2.4 GHz band, and provided that equipment operates within this limit it does not require a wireless telegraphy licence in Ireland.

Furthermore, this recommendation specifies power levels between 200mW and 1W in the 5GHz band for Hiperlan equipment (see Section 5.5.1 below). Recommendation 70-03 refers to an ETSI standard (300 836-1) and an ERC decision ((99)23) in relation to the operation of Hiperlan equipment. This means that equipment can be operated in Ireland without a licence if it conforms to the requirements of the above standard including Automatic Power Control, Dynamic Frequency Selection, etc. IEEE 802.11a equipment currently does not yet conform to these requirements (but see Section 5.5.2 below) and therefore, for now, cannot normally be operated in Ireland[13].

WLAN systems operating to the ETSI or IEEE standards in either band that are used to provide public services would require a telecommunication service licence**.**

5.4 Spectrum

WLAN systems operate in the 2.4GHz ISM (Industrial Scientific and Medical) band and the 5GHz (Hiperlan and ISM) bands. There are also future plans for similar WLAN applications in the 17GHz band and in the longer term in the 60GHz band.

5.4.1 2.4GHz

WLANs can be used on a licence exempt basis between 2400MHz (i.e. 2.4GHz) and 2483.5MHz in Ireland in the Industrial, Scientific and Medical (ISM) band (2400-2500MHz). ISM uses have priority[14] in this band and therefore WLANs cannot be given

[11] Conference of European Telecommunications Administrations (CEPT), Electronic Communications Committee (ECC)-formerly European Radiocommunications Committee (ERC).
[12] ERC Recommendation 70-03, http://www.ero.dk/doc98/Official/Pdf/Rec7003e.pdf
[13] Temporary test licences may be granted for testing of 802.11a equipment (see www.odtr.ie/docs/odtr9915.doc)
[14] The priority of services is defined by the ITU. ISM band: ITU-R S5.150

any regulatory protection from them. In Ireland, up to 100mWatts of radiated power (EIRP[15]) is permitted in line with European requirements for this band.

The 2.4GHz band is becoming increasingly popular for a wide range of short range wireless applications in addition to WLANs, and in some circumstances this may lead to problems with reliability. Furthermore, emissions from ISM equipment including microwave ovens and industrial heaters can occur in this band. Whilst recognising the 2.4GHz band can sometimes present a harsh environment, there may also be many locations where WLANs can operate in it successfully.

5.4.2 *5GHz*

The following frequencies are allocated for WLAN applications in the 5GHz band: 5.150GHz – 5.350GHz (Hiperlan, indoor use 200mW EIRP), 5.470GHz - 5.725GHz (Hiperlan, indoor and outdoor use 1W EIRP), 5.725GHz - 5.875GHz (ISM, 25mW). In the first two bands, where there is a need for sharing with other radiocommunication services, WLANs are required to employ dynamic frequency selection and transmitter power control in order to reduce interference to these other services. This band offers greater information-carrying capacity than the 2.4GHz band, and could be used for the back haul of WLAN traffic (i.e. point to point type applications).

With respect to the 5.8GHz band, we recognise that this could provide a useful possibility for WLAN applications, particularly as there is IEEE 802.11a equipment currently available for use in this band. However, the current power limit could prevent the widespread deployment of WLANs in this band. So the ODTR is currently exploring with CEPT the possibility of increasing the permitted power to more useful levels.

5.5 Standards

There are two main bodies working on WLAN standards: the European Telecommunications Standards Institute (ETSI) and the Institute of Electrical and Electronic Engineers (IEEE). Each of these standards bodies has produced standards in the 2.4GHz and 5GHz bands.

[15] Equivalent Isotropically Radiated Power

5.5.1 *ETSI – Hiperlan/RLAN*

ETSI standards 300 328 and 300 440 apply to Short Range Devices (SRDs), including Radio Local Area Networks (RLANs – another name for WLANs) in the 2.4GHz band, (broadly equivalent to IEEE 802.11b).

At 5GHz, ETSI has a High Performance RLAN (Hiperlan 1) standard[16] for 20 Mbit/s WLANs. Few products have been developed to this standard. Hiperlan 2, also at 5GHz, is for systems up to 54Mbit/s, equivalent to IEEE 802.11a. Given that Hiperlan 2 and IEEE 802.11a operate in the same way in terms of radio transmissions[17], systems based on them should not differ significantly in cost. However, there are differences in the software protocols. For example, Hiperlan 2 uses a connection-orientated protocol (originally based on ATM[18]) and includes features for traffic management[19], which suits video and voice applications. Hiperlan 2 also includes dynamic frequency selection[20] and automatic power control that will help to prevent and mitigate potential interference with other systems.

5.5.2 *IEEE – 802.11/Wi-Fi*

The IEEE has introduced a series of standards for WLANs. The first, IEEE 802.11, was for systems operating at 2.4GHz and delivering data rates of 1-2Mbit/s. This was followed by IEEE 802.11b, for systems also operating at 2.4GHz, but with data rates up to 11Mbit/s. This standard has widespread backing, including from the Wireless Ethernet Compatibility Alliance (WECA) of major industry players. Other variations of the 802.11 standard operating at 2.4GHz are being developed (e.g. 802.11g).

For the most part, the systems currently being installed are based on 802.11b. However, IEEE 802.11a, for systems operating at 5GHz, caters for even higher data rates. Some 5GHz systems operating at 50+Mbit/s are already available. More power is consumed by equipment operating in this band which means that battery powered equipment will have shorter operation times. Systems operating up to 100+Mbit/s are expected to be available within a couple of years. Some manufacturers have developed products that can be upgraded readily from 802.11b to 802.11a, including systems that can be used in joint 2.4/5GHz infrastructures.

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[16] ETSI standard 300 652
[17] "Standards debate entangles wireless local-area networks", Wireless Europe, February 2001
[18] ATM – Asynchronous Transfer Mode
[19] Class of service and quality of service can be defined for individual traffic flows in ATM.
[20] This feature is used to avoid interference and to distribute spectrum usage, limiting the impact of multiple WLAN systems.

Currently the IEEE (IEEE 802.11j) is working on incorporating dynamic frequency selection and automatic power control into their 5GHz WLAN standards to bring them in line with European requirements. ETSI, the IEEE, and MMAC (Japan) have set up the '5GHz Global Steering Group – Globalisation and Harmonisation' to help address the interoperability and harmonisation issues. International harmonisation of this band is one of the issues to be discussed at the ITU WRC-2003[21].

5.5.3 *Others*

Home RF is a simplified version of 802.11b designed for home area networking. It uses parts of the DECT cordless phone standard to deliver voice services. Home RF has not been as commercially successful as 802.11b.

5.6 Power Limitations

5.6.1 *Range*

For internal applications typical ranges achievable are up to 100 metres at 2.4GHz. Up to 300 metres can be achieved in more open spaces. Internal applications at 5GHz can have typical ranges of up to 80 metres.

External applications of WLAN, typically in point to point or point to multi-point configurations, are capable of far greater ranges by effectively increasing radiated power using directional[22] antennas. At 2.4GHz, the following distances are typically achievable at the power limit of 100mW EIRP.

Data Rate (Mbit/s)	1	2	5.5	11
Range (km)	7	5	3.5	2.5

Table 1. Typical ranges at 2.4GHz (source: Lucent ORiNOCO Outdoor Router System)

[21] World Radiocommunications Conference-2003, agenda item 1.5.
[22] Directional antennas have higher 'Gains' and provide a more focused beam in a specific direction.

Systems operating in the 5GHz band (see section 5.4.2) including point to point external links, typically have shorter ranges than in the 2.4GHz band due to the greater attenuation of the signal in the propagation environment.

Power limitations were addressed by the ODTR in document ODTR 01/70 - "New Opportunities in the Radiocommunications Market - FWA Access". In this document it was decided that no change would be made to the current power limits defined for the 2.4 GHz band and the 5 GHz Hiperlan bands, as the Director considered that this may lead to unacceptable degradation of service quality for users of the bands. However, as mentioned earlier, the ODTR is exploring the possibility of permitting higher power levels in the 5.8 GHz band. The ODTR will continue to monitor industry and regulatory developments in the 2.4GHz, 5GHz and future bands.

5.6.2 Sharing/Co-habitation

Interference is common in the 2.4GHz band and is to be expected as the majority of devices in this band are operating on a deregulated basis without central co-ordination by a regulatory agency. The impact of such interference would cause WLAN data rates to lower. Increasing use of this spectrum by licence exempt applications would decrease its usability and users may eventually find it preferable to move elsewhere (e.g. to 5GHz). Increasing the power levels of systems simply increases the likelihood of interference to other systems.

In the 5GHz band high density applications of this type are still developing so potential impacts are difficult to predict. However, detailed studies have been undertaken by CEPT in the use of this band resulting in the ETSI Hiperlan standards (see Section 5.5.1). This band is shared with other services such as Fixed Satellite Services, Radio Frequency Identification Systems, and Radar Services[23], which have priority over WLANs in various parts of this band. For example, feeder links in the mobile satellite service have priority over WLAN applications in the 5.150-5.250GHz band and therefore require protection. The use of the 5GHz band in Ireland will be considered further in a forthcoming consultation on Fixed Wireless Access (FWA).

[23] Also: Aeronautical Radionavigation, Earth Exploration Satellite, Space Research and Radiolocation Services

6. Conclusion

WLAN technology presents an opportunity to help develop broadband applications and access in Ireland. It is capable of being used in conjunction with, or in some cases as an alternative to other technologies such as DSL, optical networks, 3G, cable and satellite television. Readily available WLAN technology (mainly 802.11b) is already being used in some offices, shops, universities, hotels and homes. Expected price decreases and heightened public awareness look set to further increase the take-up of WLAN technology. New technologies with even greater capabilities, such as those operating in the 5GHz band, are likely soon to become widely available, and these should further enhance the appeal of WLAN networks and applications.