

RECOMMENDATION ITU-R M.1651*

A method for assessing the required spectrum for broadband nomadic wireless access systems including radio local area networks¹ using the 5 GHz band

(Questions ITU-R 212/8 and ITU-R 142/9)

(2003)

Summary

This Recommendation provides a method for assessing the required spectrum for broadband nomadic wireless access (NWA) systems including radio local area networks (RLANs). Annex 1 gives a general description of RLANs, the deployment scenarios, an overview of the method for estimating the required spectrum as well as an example calculation in the 5 GHz band.

The ITU Radiocommunication Assembly,

considering

- a) that there is a need to estimate the actual spectrum requirement for broadband nomadic wireless access (NWA) systems, including radio local area networks (RLANs), used in various environments;
- b) that Recommendation ITU-R M.1390, which is used to calculate the spectrum requirement for the IMT-2000 terrestrial component, would be a suitable basis for the development of a new method as stated in *considering* a),

recommends

1 that the method described in Annex 1 should be used as guidance to estimate the spectrum requirement for broadband NWA systems, including RLANs, using the 5 GHz band.

NOTE 1 – Abbreviations used in this Recommendation are given in Table 1.

NOTE 2 – Reference ITU Recommendations are given in Table 2.

* This Recommendation was jointly developed by Radiocommunication Study Groups 8 and 9, and future revisions should be undertaken jointly.

¹ In this Recommendation radio local area network (RLAN) is as described in Recommendation ITU-R M.1450.

NOTE – The United States of America does not agree with this Recommendation and therefore reserves its position on it.

TABLE 1

Abbreviations used in this Recommendation

AP	Access point
BPSK	Binary phase shift keying
DLC	Data link control
HDTV	High definition television
HiMM	High speed interactive multimedia
HMM	High speed multimedia
IP	Internet protocol
LAN	Local area network
MAC	Medium access control
MiMM	Medium speed interactive multimedia
MMM	Medium speed multimedia
MT	Mobile terminal
NWA	Nomadic wireless access
PDA	Personal digital assistant
PER	Packet error rate
PHY	Physical (layer)
RLAN	Radio local area network
QAM	Quadrature amplitude modulation
QoS	Quality of service
QPSK	Quaternary phase shift keying
SDTV	Standard definition television
VCR	Video cassette recorder
WAS	Wireless access systems
VHiMM	Very high speed interactive multimedia
VHMM	Very high speed multimedia

TABLE 2

Reference ITU Recommendations

Recommendation ITU-R P.1238	Propagation data and prediction methods for the planning of indoor radiocommunication systems and radio local area networks in the frequency range 900 MHz to 100 GHz
Recommendation ITU-R M.1390	Methodology for the calculation of IMT-2000 terrestrial spectrum requirements
Recommendation ITU-R M.1450	Characteristics of broadband radio local area networks
ITU-T Recommendation I.356	B-ISDN ATM layer cell transfer performance

Annex 1

A method for assessing the required spectrum for broadband NWA systems including RLANs using the 5 GHz band

1 Background

A key condition for market acceptance of NWA systems is the availability of a sufficient amount of spectrum to allow for a high-quality user experience in the presence of other uncoordinated users. A method for estimating the amount of spectrum required to support forecast market penetration, user densities and scenarios and the kind of traffic they generate is therefore needed.

A suitable basis for a method of estimating spectrum requirements for NWA systems is available in Recommendation ITU-R M.1390, which was developed for the calculation of IMT-2000 terrestrial spectrum requirements. In fact, the scope of this Recommendation states that the method can be used for other than public land mobile radio systems, and is applicable to both circuit-switched and packet-switch based radio technologies. An example calculation is included as Appendix 1 to illustrate how the method may be implemented. In this example, RLANs are used as a representative model of NWA systems.

Section 2 provides a short introduction of NWA systems and introduces user scenarios. Section 3 reviews the methodology. Section 4 then explains the implementation of the methodology for RLAN spectrum requirements. Finally, an example calculation is supplied in Appendix 1.

2 Introduction to NWA systems

NWA includes broadband RLANs, which are described in Recommendation ITU-R M.1450. Typical applications include public and private wireless access offered in homes, schools, hospitals, hotels, conference centres, airports, shopping centres, etc. Administrations, through national rules and policies, may either choose to license these devices or to exempt these devices from licensing.

Office or indoor environments generally have low e.i.r.p.s and very small radio cells on the order of 30 m radius or less. Outdoor environments generally use higher e.i.r.p.s and have larger radii.

Sufficient spectrum, among other factors, is a necessary condition to allow satisfactory performance in the presence of other uncoordinated users and is one of the key conditions for market acceptance for these kinds of systems.

Most 5 GHz air interface standards have an adaptive feature whereby the physical layer (PHY) mode may automatically adapt to the radio path characteristics. Table 3 shows the PHY modes and typical throughput for each mode. This allows most efficient use of the radio channel, but has the consequence of service area differences: the highest bit rate is only available over a fraction of the total area coverage of the lowest bit rate for any specific access point (AP). Hence in the detailed calculations an averaging over the service area is applied. Spectral efficiency in bit/s/Hz as delivered to the network layer is a function of the throughput achievable in the medium access

control (MAC) layer. The different 5 GHz RLAN standards considered here employ different MAC strategies and therefore different network layer throughput. For the spectrum requirements calculation, the best achievable throughput has been assumed, as per Table 3. This gives a lower limit for the required spectrum: lower MAC throughput results in a greater amount of spectrum required in any given environment needed to support the same aggregate user traffic.

TABLE 3

Example RLAN MAC throughput with 1 500 byte packets

PHY mode (Mbit/s)	Coding rate	Maximum throughput	
		Mbit/s	Throughput (%)
6	1/2	4.6	77
9	3/4	6.9	77
12	1/2	9.2	77
18	3/4	13.9	77
27	9/16	21	77
36	3/4	28	77
54	3/4	42	77

2.1 Recommendation ITU-R M.1390 terminology in the RLAN context

RLANs can be considered a complement to IMT-2000 systems, providing higher data rates and system throughput in geographically limited areas (range of the order of 100 m). Multimedia services are defined in Recommendation ITU-R M.1390 as MMM, HMM and HiMM with user bit rates from 64 kbit/s to 384 kbit/s and up to 2 000 kbit/s. The bandwidth demands of true, high-resolution multimedia communications will require bit rates of the order of 10 Mbit/s and above. RLANs can achieve much higher data rates and system capacity. These data rates can be handled by RLAN standards in the 5 GHz band for several users simultaneously within smaller cells than IMT-2000 systems, and normally inside buildings.

RLANs are typically deployed in a cellular structure, however not with contiguous area coverage like cellular systems. Even if the RLAN coverage area is limited, the entire spectrum may be needed due to local traffic demands.

2.2 Application environments

Typical applications can be found in Recommendation ITU-R M.1450. The environments analysed here are:

- corporate office environment;
- public access environment;

- wide area access environment;
- home environment.

Each of the environments is given attributes in the sections below which should be used in the calculations.

2.2.1 Corporate office environment

RLANs can be used for the replacement or extension of wired LANs. Typical cases could be temporary office installations or installations into spaces where building characteristics or protection prohibit the extensive use of cabling. More recently the sheer convenience of untethered connection to the LAN is proving very attractive to users of laptop PCs, and RLAN products are experiencing high growth rates.

Terminals typically connected to infrastructure networks are designed for fixed use. Such a terminal could, for example, be a workstation, a PC or any other purpose-specific terminal. The applications are typically broadband applications. In this scenario the user device is mostly stationary and the main benefit derived from RLANs is the wireless convenience. Thus, it will be a most likely scenario that RLANs should provide or approximate fixed network QoS to a stationary user. The user should not be able to notice the difference between using the wireless system and a wired system.

TABLE 4

Characteristics of an office environment

Attribute	Requirement
End-user equipment	Portable PC or workstation, personal digital assistant (PDA)
Usage environment	Corporate offices, etc.
Range	Up to 50 m for indoor systems
QoS expectation	Basically same as fixed installation
Applications	Basically same as fixed installation
Mobility	Limited
Coverage	Continuous within the workspace

2.2.2 Public access environment

Typical places for using the RLAN system outside an office room would be meeting rooms, dining facilities, patient wards, classrooms and auditoria, as well as waiting rooms/halls. A user may also be able to access the public network through base stations installed in locations such as railway stations, airports and shopping centres. In some cases, connectivity has to be maintained while the user is in transit from one location to another.

The terminals in this scenario are movable. A typical terminal could be built around a laptop computer and a RLAN card. The mobile node will in many cases be a battery driven device so that an economic consumption of power is required.

Public wireless access applications are in principle similar to office environment applications. However, the users can be located in a wider variety of building types and the ranges are typically greater than in office environments. Furthermore, there may be uncoordinated networks with different owners, which can interfere with a given terminal.

The QoS expected from the RLAN system in this scenario could be somewhat lower than the QoS expected of an office or home system. The user can be assumed to accept that a small loss in QoS is the price paid for the mobility gained. For example, the connection might tolerate a short interruption because of a cell change (resulting in momentary disturbance in the video picture), and the required video picture size and definition for a person temporarily in the access area is also lower.

TABLE 5

Characteristics of a public access environment

Attribute	Requirement
End-user equipment	Portable computer, e.g. notebook or PDA
Usage environment	Offices, schools, hospitals, airports, railway stations, shopping centres, etc.
Range	Up to 50 m for indoor systems Up to 150 m for outdoor systems
QoS expectation	Somewhat lower than desktop
Applications	Similar to desktop
Mobility	Limited
Coverage	Continuous within defined area, e.g. airport hall

It is envisaged by some administrations that RLANs could be used for public access. User devices for such public access should have the same air interface as those for private access. A user device, therefore, can access both public and private networks.

2.2.3 Wide area access environment

It is envisaged by some administrations that WAS/RLANs could be used for wireless access on a wide area coverage basis. The terminals for such access should have the same air interface as indoor WAS/RLAN devices, but would likely use modified antennas and MAC protocols that allow greater range and deal with the longer propagation and multiple access delays resulting from outdoor operation. Sectoral or high-gain omnidirectional antennas, or repeaters, could be used to create micro-cells in which operational ranges of 300 to 3 000 m are possible, depending on the outdoor propagation conditions. In such deployments, the antennas are usually highly directive and are oriented toward a central AP.

The applications are classified as nomadic since the terminals are capable of being moved from location to location. Some examples of nomadic applications are the provisioning of services to small transient businesses operating from industrial parks, or the linkage of several buildings in close proximity to each other to form a “campus” wireless network.

TABLE 6

Characteristics of wide area access environment

Attribute	Requirement
End-user equipment	Desktop and laptop computer, home entertainment centre, small office network
Usage environment	Inter-building, industrial parks (campus) and communities
Range	300 to 3 000 m
QoS expectation	Basically same as a wireline installation
Applications	Basically same as a wireline installation
Mobility	Limited
Coverage	Dependent on outdoor environment and restricted to the range of cell

2.2.4 Home environment

A home network generally covers a much smaller area than either factory or office environments. The rooms tend to be smaller when compared to work environments and have more compartmentalized structure (storage spaces and en-suites). In the home environment, many appliances, e.g. PC laptop, printer/fax machines, security systems, home appliances, digital HDTV/SDTV sets, digital video cassette recorder (VCR), speakers and more could be linked in various ways. A typical scenario would be:

- An entertainment cluster (video and sound) located in the living room transmitting to television sets located in the living room, kitchen and bedroom. The wireless link provides a “bridge” between the clusters, avoiding the use of cable.
- A music system in the living room transmitting to speakers located in the living room, bedroom or dining room.
- Security features outside the home such as wireless security camera or remote sensors. These could either be located on the external walls of the property or at the boundary wall, or a remote building such as a garage or recreation facility.
- RLAN allowing sharing of home computer resources and sharing of Internet access between several computers or PDAs for simultaneous use by several family members.

From the above, it is obvious that the domestic network should allow access to external networks, e.g. digital television or be capable of working with no external links, e.g. a music system with remote speakers.