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## IMPACT OF POWER LIMITATIONS ON THE PERFORMANCE OF WLANS FOR HOME NETWORKING APPLICATIONS

S. Armour, B.S. Lee, A. Doufexi, A.R. Nix and D. Bull

University of Bristol, Centre for Communications Research, Merchant Venturers Building,  
Woodland Road, Bristol, BS8 1UB, UK

### ABSTRACT

*This paper considers the application of 5GHz Wireless LAN technology to home networking applications. An assessment of physical layer performance is presented in the form of achievable data rate as a function of received signal to noise ratio. The transmit power limitations imposed by the relevant regulatory bodies are also summarised. Based on this information, a state of the art propagation modelling tool is used to evaluate the coverage achieved by a WLAN system in an example residential environment in terms of the achieved data rate.*

### I. INTRODUCTION

Together, the IEEE 802.11a (North America), ETSI HIPERLAN/2 (Europe) and ARIB HISWAN (Japan) standards provide a worldwide definition for broadband Wireless Local Area Network (WLAN) technology operating in the 5GHz band [1,2,3]. Since these three standards all specify near-common physical layers [4] and have similar frequency band allocations, a very real possibility exists that a single broadband WLAN product could be produced that is capable of operation anywhere in the world. The ongoing attempts by the relevant standards organisations to unify their standards further strengthens this possibility.

All three standards are capable of achieving data rates up to 54Mbps/s and are thus suitable for broadband multimedia applications. One application of this new technology is to facilitate the Wireless Home Network (WHN), allowing in-home distribution of high definition audio and video without the need for wired links. The WHN application represents a huge potential market for new consumer electronics products.

In this paper, a state of the art propagation modelling tool is used to determine the performance achieved by WLAN technology in an example residential environment. To facilitate this analysis, a number of transmit power scenarios are discussed in section II. These scenarios are based on both the transmit power limitations imposed by the relevant regulatory bodies and on consideration of the available transmit power amplifier technology. Also, a link throughput analysis of the HIPERLAN/2 standard is presented in section III. The propagation modelling tool is introduced in section IV, as is an example residential environment. In section V, the performance of the WLAN

in the example environment is evaluated in terms of the achievable data rate. Results are analysed in section VI and conclusions are drawn.

### II. TRANSMIT POWER SCENARIOS

Two factors need to be considered in the development of transmit power scenarios for 5GHz WLANs: limitations imposed by the relevant regulatory bodies and limitations imposed by transmit power amplifier technology.

The transmit power limitations imposed by the regulatory bodies for 5GHz WLANs in America, Europe and Japan are summarised in table 1.

Region	Band Allocation	Limit (EIRP)
USA	5.15-5.25 GHz	23dBm
	5.25-5.35 GHz	30dBm
Europe	5.15-5.35 GHz	23dBm
	5.47-5.73 GHz	30dBm
Japan	5.15-5.25 GHz	23dBm

Table 1. Regional Regulatory Limits on Transmit Power

Due to the non-linear signal envelope resulting from the COFDM modulation scheme employed [5], all three 5GHz WLAN standards place significant demands upon transmit power amplifier technology.

Based on regulatory and technological limitations, three scenarios are defined here to represent different WHN products:

1. 1W EIRP. Achievable by mains powered devices operating only within the higher power bands available in Europe and America.
2. 200mW EIRP. Achievable by PC Card devices in any band and by mains powered devices in the lower power bands (available worldwide).
3. 1mW EIRP. Achievable by handheld devices in all bands. 1mW output power facilitates the use of low cost, power efficient, linear PA technology.

### III. LINK THROUGHPUT

Based on analysis previously undertaken and presented in [4], the link throughput performance of the HIPERLAN/2 standard is presented in figure 1. These results show the achievable data rate as a function of SNR for each of the transmission modes supported by the link adaptation. For

the purposes of this paper it is assumed that the mode offering the highest data throughput is always used for a given SNR, i.e. that the link adaptation is ideal.

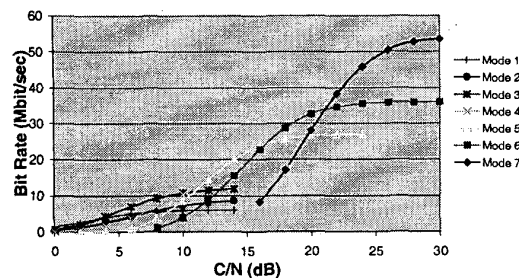


Figure 1. HIPERLAN/2 Link Throughput

#### IV. THE PROPAGATION MODELLING TOOL

The propagation modelling tool is based on a sophisticated ray launching technique. For a more detailed description of the model, the reader is referred to [6].

The example residential environment considered in this paper consists of two adjacent residences. Each consists of two storeys, each with 3m high ceilings. Construction is primarily of brick with concrete floors. The walls are 15cm thick and the floors 25cm thick. Overall dimensions are 16x11x6m. The ground floor of this environment is illustrated in figure 2. The heavy black line denotes the dividing wall between the two residential properties.

#### V. RESULTS

By application of the propagation modelling tool, the received signal power can be determined as a function of location within the environment.

Based on the received signal power analysis and the link throughput evaluation in section III, the data rate achieved by a HIPERLAN/2 unit can be evaluated as a function of location. The results of this analysis considering only the ground floor and one specific Access Point (AP) location are illustrated in figure 2 in the form of a data rate map. Note that dipole antennas were assumed together with a transmit power of 23dBm.

#### VI. CONCLUSIONS

The results presented in section V consider a specific combination of the HIPERLAN/2 standard, 23dBm transmit power, one AP location and a single antenna configuration at both AP and terminal.

It is clear from the results that the achievable data is near maximum for most of the environment. In some locations the achievable data rate falls significantly. However, the majority of these locations are not in the same residence as the AP and are thus of no concern (other than from the point of view of interference). Clearly, the system is

capable of supporting multimedia applications throughout the majority of the environment when transmitting at 23dBm. For the 30dBm and 0dBm transmit power scenarios significant changes in the achievable data rate coverage can be expected.

The combination of propagation modelling and link throughput analysis employed here facilitates a highly flexible method for evaluating the performance of WLAN technologies for WHN applications. A single example is considered here. In the full paper, the process will be extended to cover the 802.11a standard, multi-storey propagation effects, different antenna configurations and different AP locations. The analysis will also be extended to consider adjacent-residence interference.

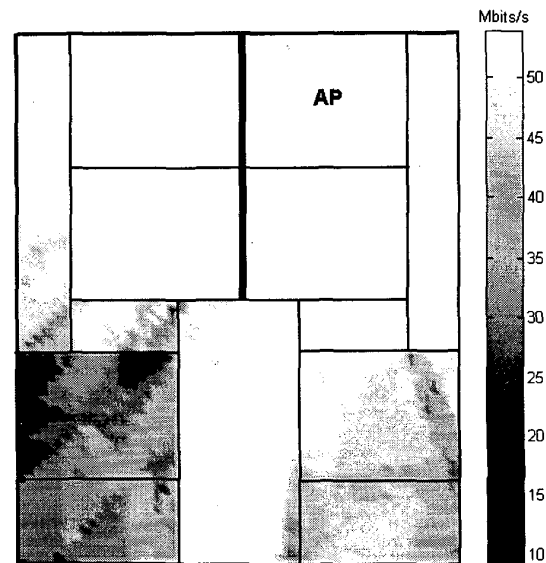


Figure 2. Residential Environment and Data Rate Coverage Plot

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