INDOOR CHANNEL MODEL FOR LINK BER ESTIMATION

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ABSTRACT

*With their low cost and high-speed data rate capabilities, installations of IEEE 802.11-based wireless local area networks (WLANs) are growing exponentially. Although many organisations have started using WLANs, there are still very few tools available that can help the design of WLAN networks. As a result, the current deployment of WLAN networks remains ad-hoc (unplanned) in nature. The objective of this research is to investigate performance of WLAN networks by optimising the position of access points. The hypothesis being that the number and positioning of access points in a large WLAN network can be optimised depending upon the structure of the building, presence or absence of obstacles in the propagation path etc. The research presented in this paper specifically addresses the effect of **moving** obstacles in the propagation path between a WLAN access point and a WLAN node, thus noting its effect on channel BER. Propagation models will be used that can predict the signal strength and interference in a WLAN system by taking into account environment specific parameters such as the structure of the building, presence or absence of **stationary** obstacles etc [1]. This paper will investigate the influence of **moving** obstacles, such as people, on radio wave propagation inside a building and the effect on received signal quality in a WLAN system. Our findings suggest that the presence of **moving** obstacles, such as people, seriously affects the performance of the system by introducing heavy variations in the received signal strength.*

EXTENDED ABSTRACT

Introduction

WLAN networks have become very popular means for providing wireless networking facility for home users, educational institutions, companies etc. due to their ease of installation and their high data rate provision, apart from providing, albeit limited, mobility to users. Most people deploy WLAN access points in the immediate vicinity of where wireless coverage is desired and the system typically seems to work. However, such an ad-hoc deployment will work only if there are very few access points. The performance of such an ad-hoc deployed network is much less than what could be achieved by proper network design. Indeed, many organisations are already noticing the actual data rate limitations of large scale, highly loaded WLANs that have been installed in an ad-hoc fashion. The optimal deployment of a WLAN system, however, should consider various factors that influence the performance of the system and the overall network performance and Quality of Service (QoS) that can be achieved. An important performance measure is the achievable throughput. Throughput depends upon the Bit Error Rate (BER), which in turn depends on the signal quality and signal to interference ratio (SIR). As the received signal quality has a crucial impact on the network performance, accurate prediction of the received SIR is important for optimal network deployment. Moving obstacles in the propagation path introduce large variations in the received signal strength due to fast fading and changing small area shadowing. Most common RF propagation prediction techniques alone are only capable of predicting the mean received signal strength.

This paper investigates the prediction of complete received signal statistics rather than just its mean value and investigates the influence of variable shadowing due to the movement of people in the propagation area and its effect on optimal network deployment and performance.

The full paper is organised as follows. Section I will give an introduction, rationale and motivation behind the current research. Section II will describe the measurement campaign conducted for the purpose of collecting data for statistical investigation into the influence of people on the received signal strength. The proposed novel method of site-specific prediction of signal statistics and SIR will be described in Section III. Section IV will demonstrate the impact of moving people shadowing on optimal network deployment, which was found to be very significant in crowded office environments. Section IV will conclude final paper.

Performance optimisation of a WLAN system

The performance if a WLAN system depends on the received signal to interference ratio (SIR). Signal to interference ratio, combined together with the modulation and coding schemes used in the system dictate the bit error rate (BER) or Block error rate (BLER). A wireless system that has been deployed in an ad-hoc fashion may exhibit a high signal strength from more than one WLAN access points, but have a low SIR, thus high BER or BLER resulting in low performance. On the other hand, a properly designed system will take into account not just the signal strength from the access point a wireless node is associated with, but also the interference that it suffers from the surrounding access points. Detailed simulation of the propagation environment will be undertaken and the effect of various parameters on the performance of a WLAN system will be analysed. The analysis will aid the design of an optimum system.

Indoor Channel Model

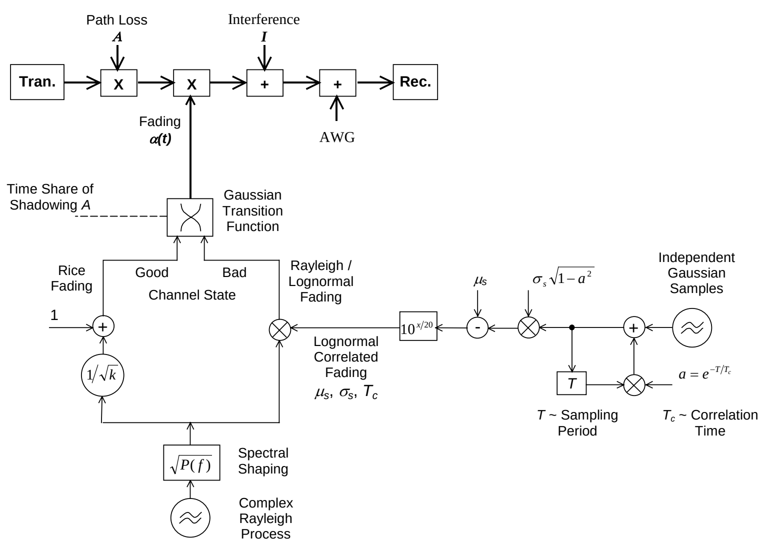


Fig 1: Indoor Channel Model considering people movement for link BER estimation

The WLAN systems deployed in indoor environments provide wireless access through access points (APs) placed in convenient places such as on ceilings, walls or some times even placed on desks near which wireless access is desired. From the radio wave propagation point of view, the signal between the AP and the user terminal propagates rather horizontally over the coverage area, crossing obstacles of various types such as desks, chairs and people etc. The net effect is an attenuation caused by static obstacles and a more varying signal due to moving obstacles such as moving people. As a consequence, there are rapid and frequent transitions between line-of-site and non-line-of-site situations, causing a variation in the statistics of fast fading, which is closely associated with the shadowing process. The characteristic of shadowing caused due to moving people resembles fast fading in propagation environments. From the modelling point of view, it is therefore most convenient to treat people shadowing and narrowband fast fading as a single entity – a closely coupled process, in which the parameters of the fading and shadowing are time-varying. Detailed measurement of WLAN signals in indoor environments is being undertaken at the Adaptive Wireless Systems Group (www.aws.ie), in order to be able to predict the mean signal and variation of signal strength in indoor environments. The overall project is expected to develop into a system capable of planning WLAN systems. Figure 2 shows an example of the variation of signal level with time in a typical indoor environment. The environment is typical with people moving in the propagation path between a fixed AP and a user terminal.

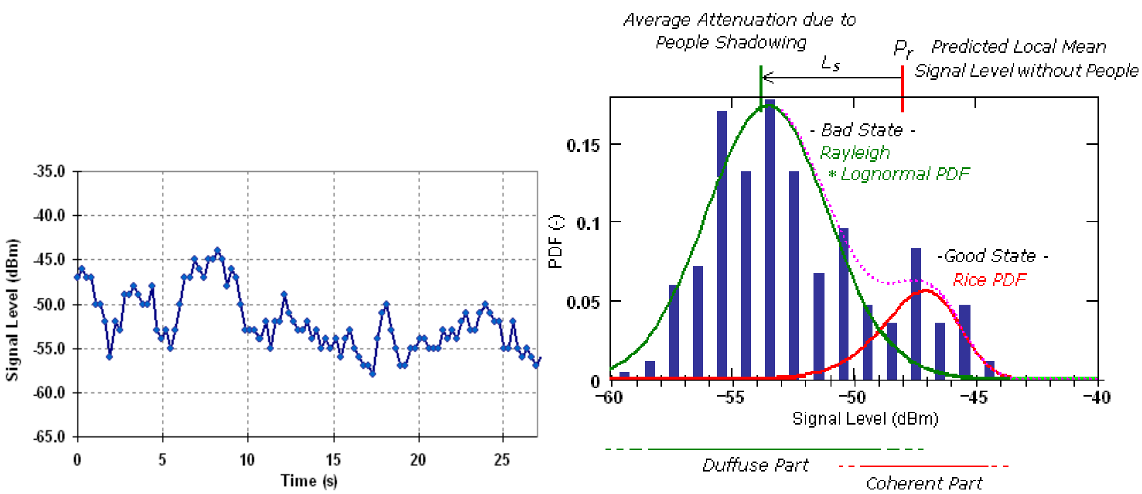


Fig 2: Example channel variations due to moving people measured in indoor environment for a fixed position of T and R and its PDF approximated by a combination of Rayleigh/Lognormal and Rice distributions.

In order to model the measured signal strength, the PDF is approximated by a combination of Rayleigh/Lognormal and Rice distributions. The indoor channel model (being developed at the AWS Group, described here) considers the effects of both, the shadowing effects (due to moving obstacles, such as people) and fast fading on narrowband propagation. The model will be specially useful when applied in combination with a deterministic model [2]. In the absence of such a model the only way to take into account the effect of moving obstacles is by using a deterministic calculation process, which is very demanding in circumstances where the number of people is highly variable. The model described here represents the channel statistics in terms of parametric distributions, which (as shown above) can be approximated by a combination of Rice, Rayleigh and Log-Normal components. The rationale behind using a combination of different distributions is that the total narrowband fading signal in indoor environments can be decomposed into two distinct parts, a coherent part, which is usually associated with the direct path between the AP and the user terminal, and a diffuse part arising from a large number of multipath components of differing phases.

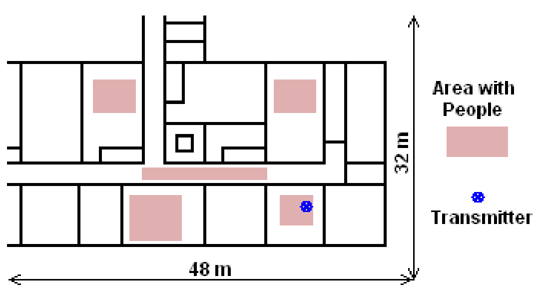
The signal variation of the coherent part is characterised by Rice distribution with appropriate *k* factor (0÷20). The signal variation of the diffuse part is characterised by the combination of Lognormal and Rayleigh distribution. The transition probability and also the time-sharing between these states will be governed by probability of people appearing in the propagation path. In order to characterise the transition between the coherent and diffuse states, a Gaussian transition function is introduced in the model, which corresponds to a Gaussian distribution of energy in the cross-section of path between AP and user terminal.

In this model, the statistics of coherent part and diffuse part are modelled by two distinct states - one while the obstacle is crossing the line of sight between the AP and the terminal; the other state prevails at other times. This is particularly appropriate for a modelling of people influence on the signal variation in indoor office environments, where moving people can severely attenuate the signal level at receiver side as they cross the line of sight. This state prevails as long as the line of sight is obstructed. A similar pattern is observed for a land mobile satellite communication system when buildings and trees block a line of sight between the satellite and the mobile station [3].

A detailed explanation of the model and the derivation of the statistical parameters will be presented in the final paper.

Environment-specific radio signal prediction

Some initial results obtained from computer simulation of a typical building having one main corridor and rooms on both sides have been shown here. The communications channel has been modelled by taking into account path-loss, shadowing by people, fast fading, interference from other transmitters and additive white Gaussian noise (AWG) as shown in Fig.1. The building is assumed to have one corridor with rooms on both sides as shown in Fig.3. A transmitter (access point) is placed at one point (shown by blue in Fig.3.) and some areas have been assumed to have a density of moving obstacles (people, marked by pink in Fig.3). In order to accurately predict the signal quality in the channel (Fig.1), at every point of the investigated scenario (Fig.3.), all parameters, except the AWG (Additive White Gaussian Noise), must be site-specifically predicted. Path loss prediction (Fig.4) is performed by a deterministic Motif Model [2]. The prediction of the standard deviation of signal fluctuation due to moving people shadowing (Fig.5) will be fully described in the final paper. The Motif model also predicts the fast fading statistics. Fast fading statistics are represented by the channel's Ricean *k* factor and are also predicted by the Motif model (Fig.6). The level of interference is changing in nature, however its variation has been mainly neglected and its local mean level, the sum of contribution from surrounding interferers, is based on the appropriately filtered mean signal level predicted from surrounding interfering Access Points and other appliances such as microwave ovens, e.g. However, the temporal influence of other appliances on an optimal network deployment need to be address in the further research.



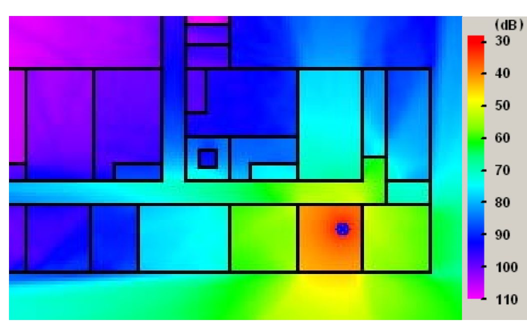


Fig. 3: Environment with specified areas of major people appearance

Fig.4:. Local Mean path loss prediction

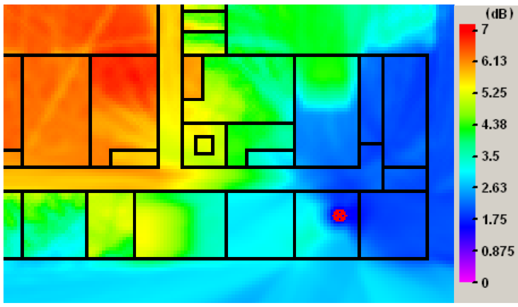


Fig. 5: Standard deviation of signal fluctuation due to shadowing by moving people

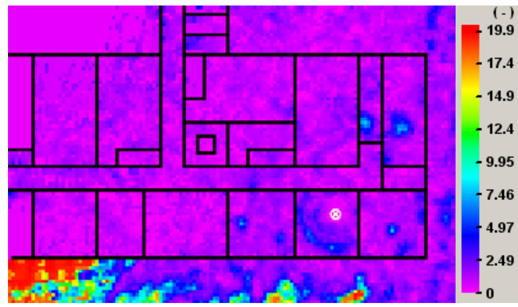


Fig. 6: Ricean *k* factor prediction for fast fading characterisation

Conclusions

This paper presents an accurate prediction of the effects of moving people shadowing in an indoor radio propagation environment and analyses its effect on the performance of a WLAN installation. In particular the effects on moving people shadowing on the optimal positioning of WLAN access point and the resulting throughout performance of the WLAN are investigated.

References

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