28 Ghz LMDS channel measurements and modeling for parameterized urban environments

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***Abstract* — This article presents results on LMDS channel modeling of a wide-band measurement campaign conducted in urban environment (Madrid-Spain). The objective of this work is to classify propagation channel impairments according to simple environmental parameters rather than to specific path profiles or vague descriptions.**

I. Introduction

The time and cost savings broadband terrestrial wireless offers are making it an attractive option for the last mile competitive market. So far satellites and hybrid cable systems (CATV and xDSL) have been extensively deemed as the natural providers of broadband services. Almost unexpectedly Local Multipoint Distribution Service (LMDS) has become a two-way broadband technology quick and inexpensive to deploy. Available spectrum is so ample in the millimeter microwave regions that spectral efficiency is not an issue at time. Carriers can build a thoroughly modern network with no legacy systems and services to maintain.

LMDS are cellular systems with cells typically spaced up to 5 kilometers (3 miles). The characteristics of millimeter wave propagation require Line-Of-Sight between the antennas of base station and customer premises to achieve reliable communications; millimeter wave is greatly influenced by the rain. In addition, other key issues such as capacity, interface and network management of LMDS system are still under investigation.

In particular, a number of channel modeling studies are currently being carrying out. However due to the different worldwide frequency allocations (from 2 to 42 GHz) , results obtained for use in one country can't be used in another, which also means vendors have to develop products for different regions. New broadband terrestrial propagation models and results are being reported at different frequencies. An initial research for LMDS is reproted in [1] where path loss and reflexion were assessed. In [2] LMDS channel dispersion at 28 GHz is evaluated by means of ray tracing. In [3] and [4] a novel and simple excess path model along with static and time variant channel models are presented. The authors conducted a measurement campaign at 27.4 GHz in urban, suburban and rural environments of Singapore. Wideband measurements at 38 GHz and statistical propagation models are presented in [5]. In this case the rain effect is also characterized. Also from measurements at 27.4 a tapped delay line channel model is presented in [6]. In [7] the foliage attenuation is investigated and compared at 29.5 and 5 GHz and attenuation up to 10 dB are shown.

In all these reported channel models, environment is scarcely parameterized in terms of urban density or geometric attributes. This might be due to the fact that LMDS systems are first aimed at individuals, mainly SOHO users, since Wireless Local Loop is uncertain yet as an immediate LMDS application. In any case extrapolation or not of the results to other urban environments is not straightforward. For example, reported delay spreads for generic urban areas show significant disagreements from one measurement campaign to the others.

We are proposing here a well-defined parameterization of urban areas, namely as a function of statistical heights and width distributions. It is worth to note that within a given urban environment several mean heights can be found depending on the district (city, historical center, shopping area, etc). This fact is reflected in our study where different districts were analyzed in Madrid. From our study different urban areas from European or not European countries can be compared to our results by means of average statistical urban geometrical properties.

II. Overview Of The MEASUREMENT CAMPAIGN

a) Description of the environment.

As it was described in the introduction, we are proposing a simple parameterisation of the urban environment. Namely, building heights of a number of urban districts were selected, studied and parameterised. High and medium built-up density areas from Madrid (Spain) were analysed. Four different sectors of Madrid were investigated and heights were found to be normally distributed. Study of widths of buildings, lanes, sidewalks and other effects such as frequency of squares were also investigated. Table 1 shows the parameters of heights distributions. It should be noted that since these distributions describe heights, it should be more appropriate to designate them as truncated distributions.

Table 1. Building Height Distributions

Location	**General Description**	**Distribution**
Zone 1	Business area, very high buildings	Normal μ = 21.4 m, σ = 8.9 m
Zone 2	Residential area, old buildings with few stores	Normal μ = 12.5 m, σ = 3.7 m
Zone 3	Historical and shopping center of Madrid	Normal μ = 10, σ = 2 m
Zone 4	Residential area, new individual houses	h < 9 m 5 % h = 9 m 70 % h = 12 m 20 % h > 12 m 5 %

b) ***Measurements system***.

The proposed environments were measured using a time domain channel sounder whose characteristics are described in Table 2.

The behaviour of typical LMDS systems was simulated using a wide beam antenna for the transmitter and a more directional antenna for the receiver. The transmitter antenna was a horn with 20 dBi gain and a 3 dB beamwidth of 45º in azimuth and 6º in elevation. The receiver uses a more directive horn with a gain of 35 dBi and a 3 dB beamwidth of 3º in azimuth and elevation..

Table 2. Characteristics of the Channel Sounder

Technique	Sliding correlator
Frequency	27.4 Ghz
EIRP	43 dBm
Bandwidth	50 Mhz
Sensitivity	-100 dBm @ 30 dB SNR
Code chip rate	25 Mchip/s
Code chip length	1024
Time resolution	40 ns
Measurement rate	100 profiles per second

With this system measurements were taken in different location of the four parameterized environments. The transmitter was located in high buildings or towers and the receiver was moved in an area from 500 m to 5 Km around it.

All the measurements were taken in line-of-sight. And example of the delay profile measured in Zone 1 , moving the receiver several wavelengths with its antenna pointing to the transmitter, at a distance of 1 Km in partially blocked condition is shown in Figure 1. In this figure Z axis represent amplitude relative to LOS condition.

These measurement has been processed computing statistics of excess path loss, mean delay, RMS delay spread and correlation bandwidth. Table 3 shows the results for the different environments measured.

III.CONCLUSION

The results obtained permit to accurately characterize the different environments used for LMDS. We can see a very high excess path loss in Zone 1, business area with high buildings, where we have a strong multipath with high Rice factor. In zones 2 and 4 the results are very similar with lower influence in the propagation. Finally historical and shopping centre has the lower delay spread of all the three areas measured.

These results can be easily applicable to other cities with areas with similar building distributions

Figure 1.

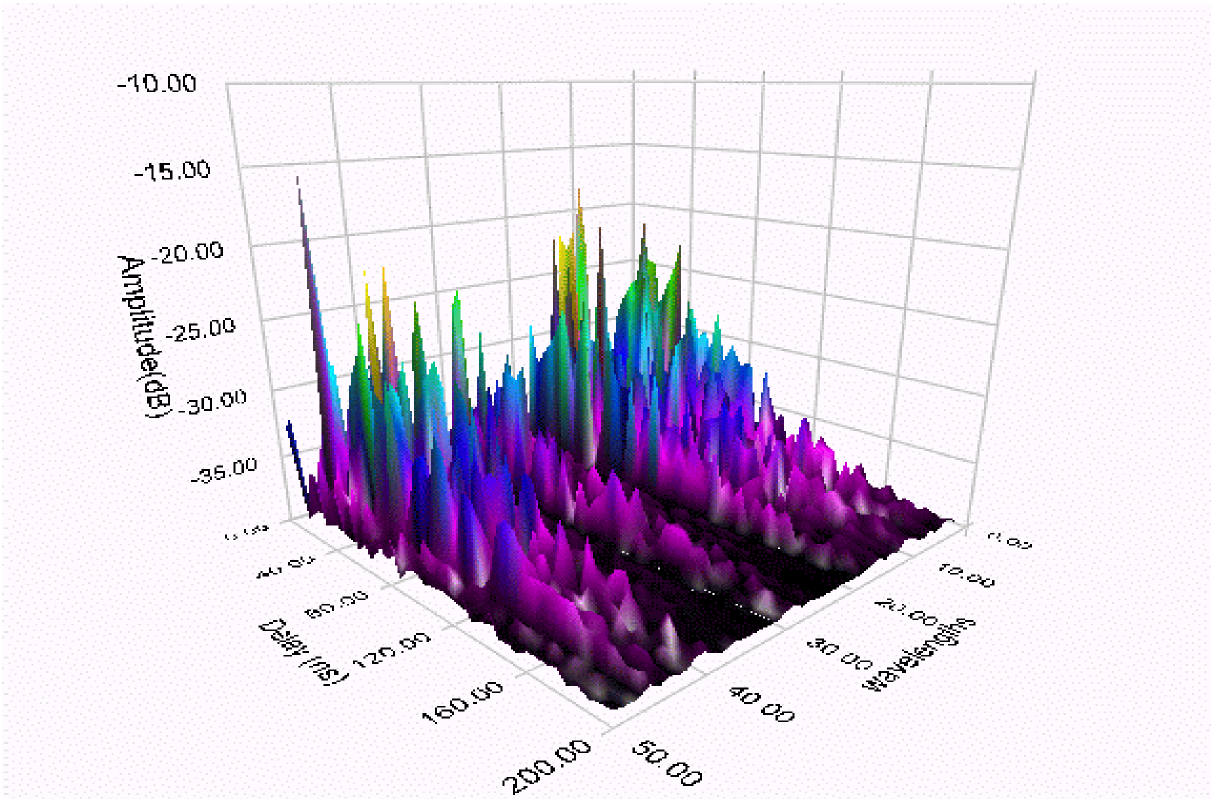

Table 3. Parameters obtained for the different locations

Location	**Zone 1**
Received power	-50-100 dBm
Mean delay	60-380 ns
Delay spread	50-200 ns
Rice factor (K)	-3-12 Db
Excess path loss	10-60 dB

.Location	**Zone 2**
Received power	-50-100 dBm
Mean delay	140-680 ns
Delay spread	150-300 ns
Rice factor (K)	-13-25 dB
Excess path loss	3-6 dB

Location	**Zone 3**
Received power	-50-100 dBm
Mean delay	40-150 ns
Delay spread	50-60 ns
Rice factor (K)	-8-15 dB
Excess path loss	8-12 dB

Location	**Zone 4**
Received power	-50-100 dBm
Mean delay	150-580 ns
Delay spread	100-150 ns
Rice factor (K)	-12-21 dB
Excess path loss	4-6 dB

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