

CHARACTERIZATION OF WiMAX PROPAGATION IN MICROCELLULAR AND PICOCELLULAR ENVIRONMENTS.

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Introduction:

The design and the deployment of wireless broadband access systems, and notably of WiMAX [1], represents nowadays one of the main challenges for telecommunication service providers, which need to perform cost/performance analyses, the costs being related to infrastructure deployment, required bandwidth and power consumption and the benefits to offered bit rate and coverage.

Different coverage strategies are envisaged to guarantee higher bit rates both in outdoor and indoor environments. In order to support WiMAX broadband mobile access also in indoor environments the introduction of WiMAX picocells and femtocells is needed in addition to conventional macrocellular and microcellular base stations. Due to the high penetration loss at the 3.5 GHz WiMAX frequency operation, pico and/or femtocells base stations are likely to be essential to provide good indoor service quality.

Therefore, a layered cellular structure is foreseen for WiMAX coverage. This implies that propagation phenomena will be very different for each cellular layer and a suitable and adaptable propagation model will be required to correctly evaluate WiMAX coverage in all different propagation conditions.

The basic aim of this paper is to study in detail propagation characteristics at WiMAX frequencies in microcellular and indoor environments and to characterise basic propagation phenomena such as street-corner effect and indoor penetration loss.

Measurement equipment and campaign

In the first part of our study we compare statistical propagation models available in literature for WiMAX systems with experimental results. Different models have been considered for path loss evaluation, such as the COST 231 Hata model [2] and the Stanford University Interim (SUI) model [3].

Different sets of dual-polarized measurements were taken [4], in an outdoor scenario in the city of Bologna and in an indoor scenario at the Villa Griffone Laboratory located in Pontecchio Marconi, which is a suburban hilly area about 15 Km from the city centre. In the outdoor scenario the WiMAX antenna was installed

in a terrace of a building while in the indoor scenario it was located both inside and outside the lab building.

The installed WiMAX equipment is a Alvarion BreezeMAX 3000 μ BS (micro-Base Station), the duplexing frequency range is 3499.5-3553.5 MHz and 3550-3600 MHz for downlink (DL), and 3399.5-3453.5 MHz, and 3450-3500 MHz for uplink (UL) [5]. The ODU (outdoor data unit) was operating at 3551.75 MHz (DL) and 3451.75 MHz (UL), the maximum transmitter power is 28dBm and the omni antenna gain is 10 dBi.

In the first outdoor scenario receiver measurements were performed in streets (outdoor measurements) at different speeds (pedestrian and vehicular) while in the second scenario (Villa Griffone) measurements were taken only inside the building (indoor measurements). As an example, in Figure 1 a comparison between measured and predicted path loss is shown for one of the urban outdoor microcellular measurements which corresponds to a street corner path route. The street corner effect is a critical propagation condition difficult to be modelled with a statistical approach. Measurements were taken with both a Customer Premises Equipment (labelled CPE) and a spectrum analyser (labelled SA).

The BreezeMAX CPE Si (Self-installable) is an indoor device and has six built in antenna elements with 9dBi gain and an optional 12 dBi external antenna (used for car measurements).

It can be noticed from Fig. 1 that in this case the COST 321 urban and the SUI urban propagation models tend to overestimate the measured path loss, while the COST 231 suburban propagation model shows a better agreement with measurements results. From the figure we observe the street corner effect occurring around measurement point 8 which causes a sudden increase in the path loss in the order of 20 dB.

Another comparison between measurements and simulations, for car routes in urban outdoor environment, is shown in Fig. 2, where the sample points are ordered as a function of the distance from the BTS. In this case over 300 measurements were performed with the CPE only. As can be noted receiver signal strength undergoes high fluctuations due to fast and slow fading related to the considered complex urban environment. Also in this case the COST 231 urban and SUI urban models overestimate the path loss while the COST 231 suburban

fits well measurements points although it tends to overestimate path loss for short distances and does not accurately follow signal fluctuations.

In the final version of the paper we will give a more detailed analysis of the outdoor measurements and also present the results for the indoor environment that can't be adequately discussed here owing to space limitations.

Using ray-tracing tool to improve existing models

In order to study more in detail propagation phenomena such as reflections, diffractions, street corner loss, transmission through walls etc., a 3-D ray-tracing tool [6]-[7] will be used to estimate the received field strength in each different measurement path route. As could be expected, the prediction error by using a full 3-D ray-tracing tool is very low with respect to the corresponding one obtained with the statistical propagation models.

The 3-D ray-tracing tool will be applied extensively in both scenarios (urban outdoor and indoor) in order to identify a novel statistical prediction model which well fits measurements results in the different propagation conditions that we intend to study.

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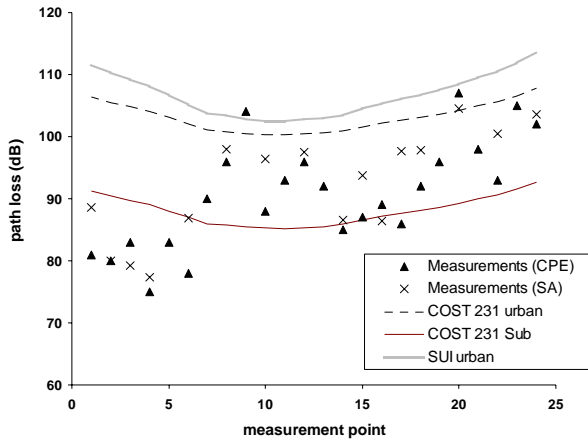


Fig. 1: Example comparison between measurements and propagation models for an outdoor pedestrian route.

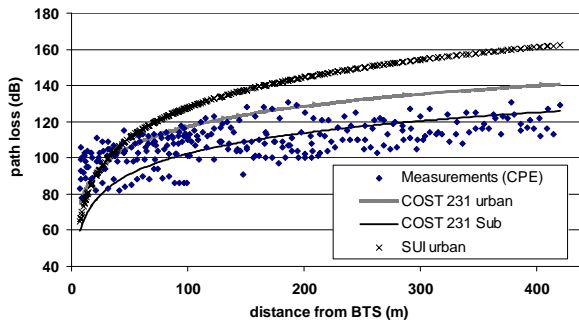


Fig. 2: Example comparison between measurements and propagation models for car routes: path loss versus distance from the WiMAX Base Station.