A STUDY ON SCATTERING FROM OBJECTS IN MICROCELL URBAN PRPAGATION CHANNEL

Mir Ghoraishi [1], Jun-ichi Takada [2], Tetsuro Imai [3]

[1] ***Department of International Development Engineering, Tokyo Institute of Technology, Japan, Email: mir@ap.ide.titech.ac.jp***

[2] ***As [1] above, but Email: takada@ide.titech.ac.jp***

[3] ***Research and Development Center, NTT DoCoMo Inc., Japan, Email: imai@mlab.yrp.nttdocomo.co.jp***

ABSTRACT

We analyze the urban propagation channel through careful investigation of the data obtained from a series of wideband measurements. We try to estimate the wave scatterers in the channel by comparison of the cluster received waves appearing in the directional power delay profiles (PDP) to precise maps of the environments including all present objects. The analysis of the measurement results shows that a significant amount of received power has been scattered by identified objects. These objects are signboards, street lights, traffic signs, traffic lights, electricity cable boxes, vending machines and generally any metallic object in the vicinity of any of Tx or Rx up to 100 meters. The contribution of the identified objects scattering to the non-LoS part of the received signal can be up to 40%.

INTRODUCTION

Recent researches on mobile radio channels has revealed that the received waves approach from finite distinct directions with different delays to the receiver. This is because the scatterers are not usually distributed uniformly throughout the whole coverage area, but rather occur in clusters [1],[6],[9]. In the macrocell it has always been assumed that building wall reflections and corner and roof edge diffractions are the dominant propagation mechanisms. Furthermore, different measurement analyses in urban macrocell environments show that there are a few strong scatterers delivering a significant fraction of received power. In small macrocellular environments the scatterers are basically building walls and buildings corner and roof edges [8],[11].

On the other hand some measurements assisted with high resolution data processing uncover that in the smaller cells, some objects other than buildings have been involved in the scattering of the received waves [2]. Even in macrocell environment, scattering from lamppost has been reported in [8]. Toward a precise understanding of the microcell channel, further investigation and evaluation of different propagation mechanisms in the urban areas seems to be necessary. To fulfill this need, researches on nonspecular scattering from building facades [3],[4],[10], and scattering from trees [5] have been done and the results were published recently. These are not however the only elements affecting the urban microcell channel. In a dense urban area there are several other typical objects which can potentially cause scattering. The objective of this work is to investigate these potential objects and evaluate their contribution to the channel.

MEASUREMENTS

We have accomplished a series of measurements in a dense urban area in a small microcell scenario. The transmitter (Tx) and receiver (Rx) were in a line-of-sight (LoS) configuration. Both the Tx and Rx antennas were positioned at equal height of 3 meters from the ground level.

Equipments

Antennas were mounted on the roof-tops of different cars at both Tx and Rx. The Tx employed an omnidirectional sleeve antenna, and at the Rx a patch array as a directive antenna was used to detect the scatterers. Both Tx and Rx antennas were rotated, for different purposes. The transmitter antenna was rotated with a diameter of 0.5 meters and constant rotation speed of 5 rpm to create dynamic uncorrelated fading. This was done to average the multipath interference within the beam. At the receiver measurement was accomplished in every 3 degrees rotation of the directive antenna with vertical and horizontal beamwidths of 10 degrees. The Tx and Rx antennas were both mounted at a height of 3 meters from the ground level on the roof-tops of the different cars. At the transmitter a PN-9 sequence of 50 Mcps, corresponding to a path resolution of 6 meters, was transmitted. The correlator output the instantaneous power delay spectrum. By averaging 978 delay spectra for each of the directions, the power delay profile was produced. By using these directional power delay profiles, we are able to identify the clusters of received power in delay-azimuth domain. Table 1 shows the parameters used in the experiments.

Measurement Sites

Dense urban areas near Kannai station in Yokohama city, Japan were chosen as the measurement sites. The data obtained from measurement in two different streets will be discussed. A street of 26 meters width (location 1) and another nearby street with 18 meters width (location 2). For each measurement the Tx and Rx were located 60 meters apart in a LoS configuration and 5.5 meters from

Table 1: Parameters used in experiments

f_c		3.35 GHz
Tx	Signal	BPSK with PN-9 Sequence
	Power	40 dBm
	Antenna	Sleeve (2.2 dBi)
	Antenna Height	3 m
	Antenna Rotation	5 rpm free run
	Antenna Rotation Diameter	50 cm
Rx	Antenna	Patch Array (24.5 dBi) 10° beamwidths in Azimuth and Elevation
	Antenna Height	3 m
	Antenna Rotation	3° step (120 point for full azimuth)
	Antenna Rotation Diameter	60 cm
Tx-Rx Separation		60 m

Figure 1: Left: Measurement site location 1. Right: Measurement site location 2.

walls of the same side each. At location 1 two round of measurements were accomplished with Tx and Rx shifted 10 meters each in the same direction for the second round keeping the separation fixed to 60 meters (points 1 and 2). At location 2 measurements performed in 3 rounds. Tx and Rx were shifted 6 meters each time in the same direction to keep the separation at 60 meters fixed again (points 1, 2 and 3). In each of these points measurements were accomplished for full azimuth at every 3 degrees.
At location 1 point 2 and location 2 point 3 just in between Tx and Rx, two roads with 13 meters and 16 meters width each were crossing the main streets so that there were no building to satisfy the specular reflection condition in these two points. The measurements were accomplished during midnights with a very low traffic in the streets.

ANALYSIS

Precise maps of the area including surrounding buildings and objects are prepared. Assuming the single bounce, elliptical zoning of the scatterers in the delay domain is possible. Therefore, the map can be digitized into the delay-DoA grids, so that the scatterers can be identified on the map. A number of different visible objects could be identified as sources of scattering by this method [7]. Some other clusters, such as those inside the building zones, could not be identified as the scatterers, considering the height of the buildings. They shall be the multiply scattered components.
Figures 2 and 3 show the power-angle-profiles (PAP) for the measurements before and after the extraction of identified scattering components. The LoS component has been removed in advance to clarify how much power of the scattered waves has been identified. Note that as we have the power-delay profile (PDP) for every 3 degrees of DoA in azimuth plain, we can easily extract the LoS component in the delay domain.
A comparison of the PAPs of location 1 with PAPs of location 2 confirms that most of the received power at location 1 is approaching through DoAs close to 0° or 360° while the received power at location 2 is more distributed along the DoA axes. This may be due

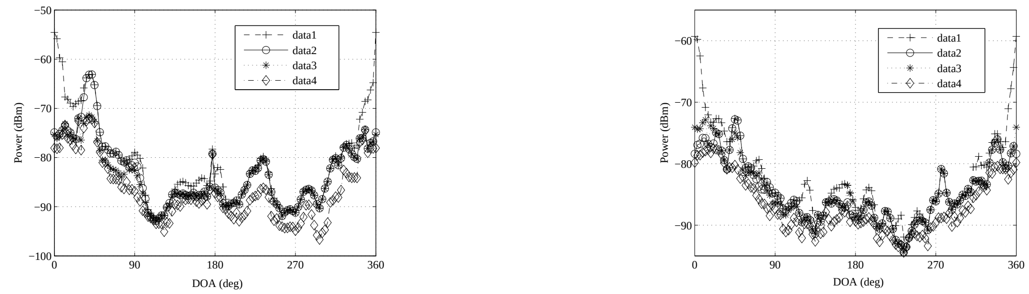

Figure 2: Left: Power-DoA profile for location 1 point 1. Right: Power-DoA profile for location 1 point 2. data 1: Received power, data 2: data 1 excluding identified objects scattering and LoS, data 3: data 2 excluding wall reflections, data 4: data 3 excluding all received clustered waves.

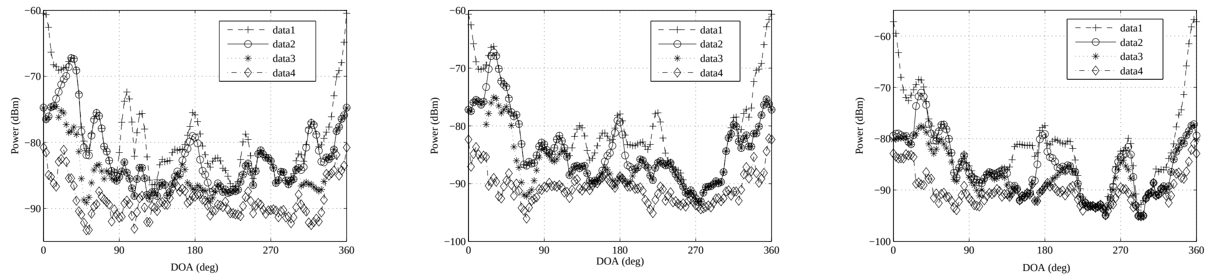

Figure 3: Left: Power-DoA profile for location 2 point 1. Middle: Power-DoA profile for location 2 point 2. Right: Power-DoA profile for location 2 point 3. data 1: Received power, data 2: data 1 excluding identified objects scattering and LoS, data 3: data 2 excluding wall reflections, data 4: data 3 excluding all received clustered waves.

to larger width of the street and lower building average height at location 1. The existence of the big trees at both sides of the street may also have caused the obstruction of the reflected/scattered waves. It has to be noticed that the measurements were performed in February when the trees were leafless and no significant scattering from trees were observed.

Careful investigation of figures 2 and 3 makes it clear that in these measurements a significant amount of received power has been scattered by the objects which we have been identified. These objects are signboards, lampposts (street lights), traffic signs, traffic lights, electricity cable boxes, vending machines and generally any metallic object in the vicinity of any of Tx or Rx up to 100 meters. Table 2 shows the number of any of these identified objects in every of the measurement locations.

In the location 1 scatterers are distributed over a larger area. Big signboards and relatively close street lights are among the strong scatterers in this area. In location 2 some building irregularities have caused strong scattering effects. Besides, we observe scattering from cable boxes and vending machines in this location as well.

Table 3 shows the contribution of propagation mechanisms for the measurements. The contribution of the identified objects scattering to the non-LoS part of the received signal is at least 20% in any of the measurement points. For any of L1P2 (location 1 point 2) and L2P3 (location 2 point 3) as it was mentioned earlier there was not any specular wall reflection and therefore the wall reflected received power is lower than other cases. As it is clear from the data given in the table, the wall reflection component can vary dramatically based on the existence of the specular reflection and the street width. In the situation where there is not any specular wall reflection in the channel the scattering from objects identified in this project can be comparable to wall reflection and in any case these scattering effects are significant. In our measurements this value could be as high as 44% of the non-LoS component for L2P3 case.

CONCLUSION

This research makes it clear that the objects as small as 40×40 (cm) traffic signs are a potential source of significant scattering in the urban microcell propagation channel. It also reveals that any metallic object like signboards, street lights, traffic signs, traffic lights, electricity cable boxes and vending machines in the vicinity of any of Tx or Rx up to 100 meters is a potential source of significant scattering in the propagation channel. Any prediction of the urban propagation channel needs to carefully consider and evaluate these scattering effects.

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Table 2: Identified Objects Description

Identified objects description	No in location 1	No in location 2
Signboard	15	8
Lamppost (Street light)	7	14
Traffic sign	10	10
Traffic light	10	2
Cable box	0	3
Vending machine	0	2
Others	4	15

Table 3: Propagation Mechanism Power Contributions

Propagation Mechanism	L1 P1	L1 P2	L2 P1	L2P2	L2P3
LoS Component	70%	74%	53%	64%	84%
Identified Object Scattering	6%	6%	15%	9%	7%
Wall Reflection	14%	4%	19%	15%	4%
Remained Received Clustered Waves	3%	7%	9%	10%	3%
Others	7%	9%	3%	2%	2%
Contribution of Scattering from Identified Objects to non-LoS component	20%	23%	32%	25%	44%

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