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Identification of Relatively Strong Clusters in an NLOS Scenario at a Small Urban-Macrocell Mobile Station

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Abstract

We present a procedure for identifying clusters around the mobile station of a small macrocell. It is based on the parameters of stronger clusters, which serve as the initial centroids. Using this method clusters were identified in an NLOS scenario. Employing this approach may aid in the identification of clusters when relatively strong paths below the centroids are included.

1. Introduction

The need to model the collection of multipaths that lie in the same angle-delay domain [1], or clusters, is also one of the things needed to approach the full performance advantage of Multiple-Input Multiple-Output (MIMO) systems for future cellular communications. Although different researchers may have various ways of defining a cluster, as their size and location highly depends on the physical layout of the considered scenario, we continue to join the effort of characterizing them. Many of the current research results in characterizing clusters focus on microcells and picocells but not on macrocells. In this paper we present a way of identifying clusters in a non-line-of-sight (NLOS) scenario at the mobile station (MS) of a small urban macrocell.

2. Channel Sounding Setup

We used the Medav RUSK-Fujitsu channel sounder [2] in the measurement. Certain details of the MIMO channel sounder are summarized in Table 1.

Table 1: Specifications of the MIMO channel sounder.

Carrier frequency	4.5 GHz
Bandwidth	120 MHz
BS antenna	uniform rectangular patch array; 4-by-2 config. vertically & horizontally polarized elements
MS antenna	stacked uniform circular patch array; 24-by-2 config. vertically & horizontally polarized elements
Tx signal; power	multitone (385 tones); 40 dBm
Maximum path delay	3.2 μs

The NLOS measurement route was in Kawasaski City, Kanagawa, Japan. A small urban macrocell was investigated with a base station (BS) height of ~85 m, while ~1.80 m for the MS, which was about 320 m ground distance from the BS. Dynamic measurements were conducted after midnight. Figure 1 shows the location of the BS and MS. Offline data processing was done to extract the azimuth and elevation angle of arrival, the azimuth and elevation angle of departure, the delay time, and the amplitude of the four polarimetric components of the paths. The extraction was done using a maximum likelihood multidimensional parameter estimation algorithm [3]. This algorithm is based on the double-directional channel concept, which makes the results independent of the antennas used.

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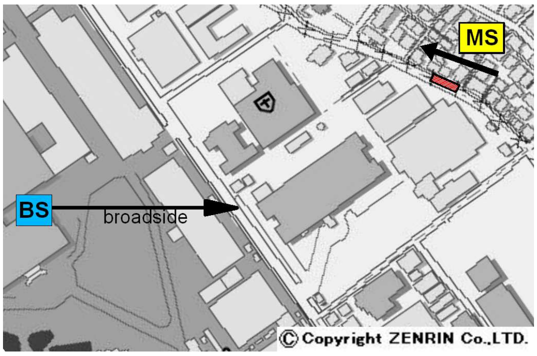

Figure 1: Channel sounding route.

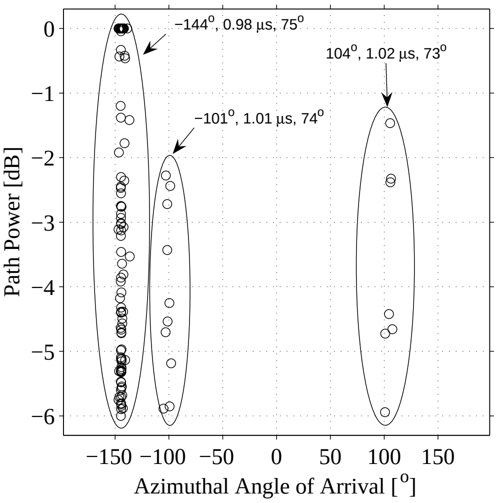

Figure 2: Initial clusters defined. Order of the arrow label: the mean azimuthal angle, the mean delay time of arrival, and the mean elevation angle of the centroids.

3. Identified Clusters

The clusters were identified from a selected MS measurement route of the NLOS scenario. Below were the steps we took in identifying them.

1. *Define the initial clusters of a scenario by considering stronger paths. The parameters of these paths describe the initial cluster centroids, which can be defined as the nucleus of a hyper-sphere. Multipaths in a cluster, given their multidimensional parameters, can be thought of as contained in a hyper-sphere separated by their multipath component distance* [4]. *Using the parameters of stronger paths as initial cluster centroids draws other paths toward strong powers* [5]. *Thus, the strength of these centroids serves as weights assigned to the parameters. A parameter of the centroid is determined by using a certain measure of its central tendency (mean, median, mode), which depends on the parameter's data. In our case we used the mean.*

Only the specular paths were accounted for as clusters throughout this paper, and the power of the initial cluster centroids that we considered ranged from −6 dB to the normalized strongest path of 0 dB. These cluster centroids were determined by identifying the multipaths that lie in the same angle-delay domain. Figure 2 shows the path power against the angle of arrival of these initial cluster centroids. Knowing these centroids enabled us to identify clusters when we included those that were lower than −6 dB, as lower powers may tend to gravitate toward those centroids.

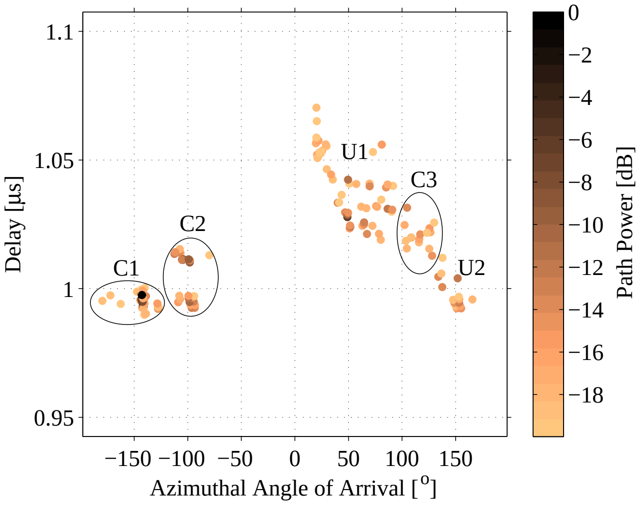

Figure 3: Time delay of arrival against the azimuthal angle of arrival of the two-meter snapshot frame. C1 refers to cluster 1, while U1 refers to unclustered paths 1.

Table 2: Scenario Parameters.

	rms delay spread [μs]	rms azimuth spread [°]	rms elevation spread [°]	XPR$_V^{BS}$ [dB]	XPR$_H^{BS}$ [dB]	XPR$_V^{MS}$ [dB]	XPR$_H^{MS}$ [dB]	CPR [dB]	% Path Power
C1	0.005	2.7	4.1	19.06	19.28	18.60	19.73	-0.67	54.35
C2	0.024	4.8	13.8	13.91	8.04	15.58	6.37	7.54	11.37
C3	0.016	8.7	9.4	9.12	9.50	9.38	9.24	-0.18	2.73
U1	0.036	19.8	9.6	15.60	10.61	15.27	10.94	4.66	9.29
U2	0.017	8.5	15.4	7.29	6.24	7.52	6.01	1.28	2.31

2. *Now including all the considered paths, identify the initial clusters by grouping paths that belong to the same azimuthal angle-delay domain according to the previously defined initial cluster centroids. Thus the grouping is aided by the initial centroids. Further separation of the clusters may also be seen from their elevation angle-delay domain using the same procedure.*

3. *After identifying the total number of clusters, relate them to their Interacting Objects (IOs)* [6] *in the measured scenario. Then, considering the resolution of the channel sounder (e.g. Fourier resolution), the accuracy of the estimation algorithm, and the inherent errors of other instruments that were used, adjust the number of clusters by regrouping or ungrouping them with other clusters.*

The paths we considered were until 20 dB below the normalized strongest path (0 dB). We chose a two-meter snapshot frame (containing five snapshots) since the paths within it did not change considerably during the measurement. The azimuthal angle-delay domain plot in Fig. 3 shows that after we included the paths below −6 dB more clusters can be seen. Using this plot was easier than using the elevation angle-delay domain in identifying the clusters of this scenario. The encircled clusters were those near the initially identified cluster centroids. Their calculated parameters are in Table 2. The cross-polarization ratio (XPR) in Table 2 is the mean XPR of the paths, in which their dB value was used, assuming the log-normal distribution. In a similar way, this was done in calculating the co-polarization ratio (CPR). The XPR notation is as follows, e.g. XPR$_V^{BS}$ is the mean XPR at the BS for vertically polarized (V) signals sent from the MS. As can be seen in Fig. 2, C1 in Fig. 3 had the largest concentrations of multipaths. The results also show that each cluster is unique, which might indicate that traditional uniform distribution of scatterers around the MS is not always appropriate. Overall, the identified clusters

(a) (b)

Figure 4: IOs viewed from the MS. (a) IOs related to C1. (b) IOs related to C3.

accounted about 68% of the path power with respect to the total power (including the diffuse components), which can show that the method can likely identify relatively strong clusters in the given context. As an example of the IOs related to the identified clusters, Fig. 4(a) and Fig. 4(b) show the IOs associated with clusters 1 and 3, respectively. However, there is still a need to group the unclustered paths in order also to characterize their behaviors. Relating these unclustered paths to their associated IOs made it also difficult to group them.

4. Conclusions

Relatively strong clusters were identified in an NLOS scenario at the MS side of a small urban macrocell. Using the centroids of the stronger paths enabled us to identify clusters when all of the considered paths were included. Scenario parameters of the clusters were obtained, however, there remains some unclustered paths that may not easily be identified by the procedure. This work may augment the initial selection of cluster centroids in automatic clustering, in addition to randomly choosing them [5].

Acknowledgments

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