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市街地伝搬路における支配的な散乱物体の特定

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キーワード　散乱，都市モバイルチャネル，指向性アンテナ

Investigating Dominant Scatterers in Urban Mobile Propagation Channel

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Abstract　The data obtained from a series of wideband directional measurements performed in an urban area in a microcell scenario is analyzed. We try to estimate the dominant scatterer objects in the propagation channel comparing the data obtained from experiment and accurate map of the area which includes all present objects. Results show that all metallic objects in the transmitter and receiver vicinity have a significant impact on the propagation channel.
Key words　scatterer, urban mobile channel, directive antenna

1. 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], [4], [7], [8]. Measurement analyses in urban macrocell environment show that there are a few strong scatterers delivering a significant fraction of received power. In small macrocellular environments the scatterers are basically building edges, walls and roof edges [5], [6], [9]. On the other hand some measurements assisting with high resolution data processing uncovers that in the smaller cells, some objects other than buildings have been involved in the scattering of the received waves [3], [2]. In most of these results, a significant amount of the received energy have been delivered by one bounce scattered waves.

The aim of this work is first to confirm the clusterized nature of the receiving waves in the urban microcellular channel and then to identify the dominant scatterers in such an environment. To this end we have accomplished a series of measurements in a typical urban area in a small microcell scenario. The transmitter and receiver were in a line-of-sight (LOS) configuration with equal height of 3 meters from the ground. The results show that most metallic objects within a distance of 200 meters from transmitter and receiver can be identified as an important scatterer.

2. Test Equipment

The block diagram of the system is shown in Fig.1. Antennas were mounted on the roof-tops at both transmitter and receiver. The transmitter employed an omnidirectional sleeve antenna, and at the receiver a patch array as a directive antenna was used to detect the scatterers. Both transmitter and receiver 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

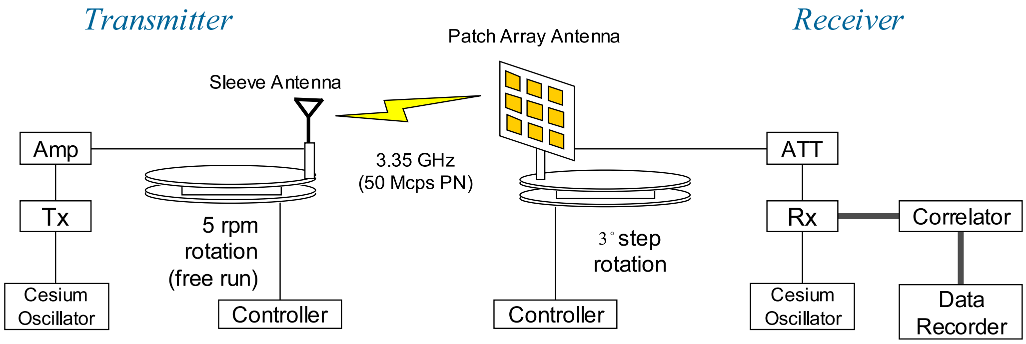

Figure 1 System Block Diagram.

Table 1 Parameters used in experiments.

f_c		3.35 GHz
Tx	Signal	BPSK with PN-9 Sequence
	Power	35 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 (15 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 2 Measuement site viewed from Rx location. Up: North, Below: South.

beam. At the receiver the measurement was accomplished in every 3° rotation of the directive antenna with vertical and horizontal beamwidths of 10°. The transmitter and receiver antennas were both mounted at a height of 3 meters on the top of the different cars. At the transmitter a PN-9 sequence of 50 Mcps, corresponding to a path resolution of 6 meters, was being transmitted. At the receiver, the signal was received for every 3° of the direction. 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.

3. Measurement Site

Fig. 3 shows the map of the measurement site, an urban area near Kannai station in Yokohama. The transmitter and receiver were located 60 meters apart in a line-of-sight configuration. The street width was 26 meters and both transmitter and receiver were located 5.5 meters from walls of the same side. Surrounding buildings had an average height of 20 meters. Just in between Tx and Rx, a road with 13 meters width was crossing so that there was no buildings to satisfy the specular reflection condition. The measurements were accomplished during midnights with a very low traffic in the street. Fig. 2 shows the north and south views of the measurement site taken from the receiver location.

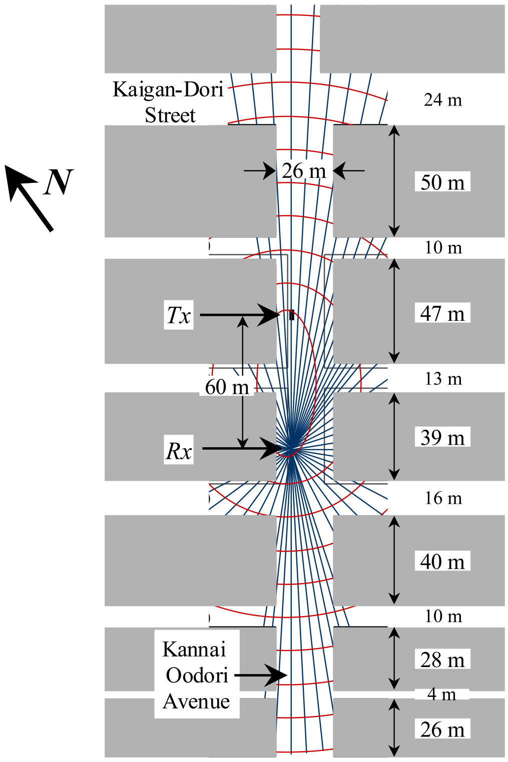

Figure 3 Measurement site.

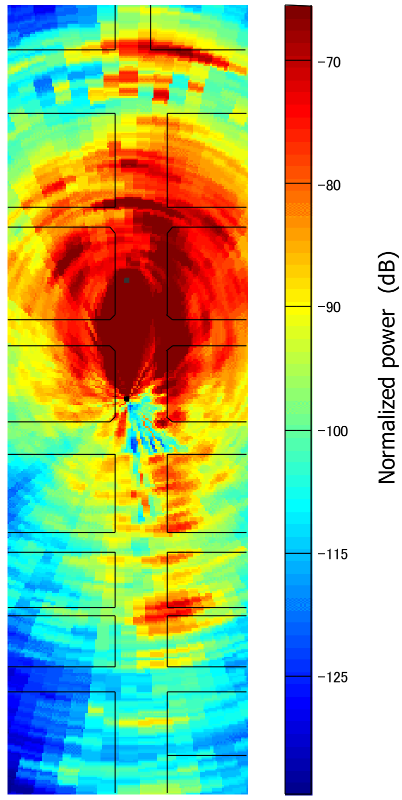

Figure 4 The received power distribution assuming single bounce.

4. Identification of Scattering Objects

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, as shown in Fig. 3, where for the sake of visibility only selected grids are sketched. Using these grids the scatterers can be identified on the map. Fig. 4 shows the the distribution of clusters, assuming the single bounce. A number of different visible objects could be identified as sources of scattering by this method. 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. Fig. 5 shows the power angular profiles before and after the extraction of identified scattering components. Note that LOS component has been removed in advance to clarify how much of the power of the scattered waves has been identified.

In Fig 6 seven areas can be recognized in which the identified scatterers have delivered a significant amount of received power. Signal scattering in each of these areas has been caused by one or a set of scatterer objects. The distribution of the scatterers of each set in the experiment environment is shown in Fig. 7. The description, rough dimensions and power contribution for each scatterer can be found in Table 2. The last column of this table shows the excess loss for each scatterer, which is calculated taking into account the free space loss for scattered waves. In the following we will try to inspect the characteristics of the scatterers in each of the sets.

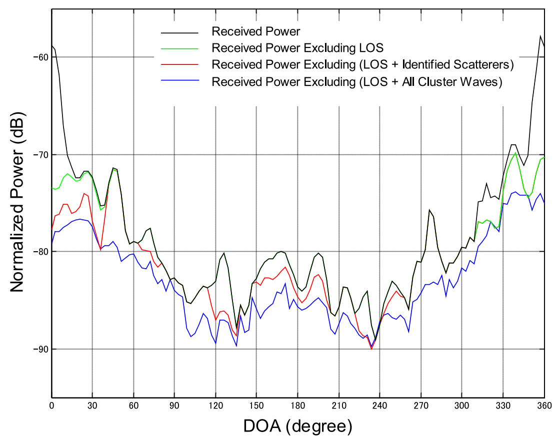

Figure 5 Power angular profiles before and after the extraction of LOS, identified scatterers and all clusters.

Set A. In the scatterers set A we have observed a number of different objects carrying a considerable amount of the received power. Direction of arrival for the received signals corresponding to this set are between 0° and 40°. The objects are located

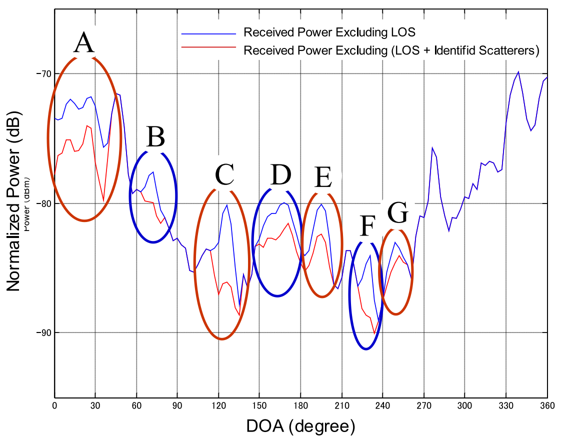

Figure 6　Identified scatterer sets.

along the street at the north of both transmitter and receiver (in a more distant location to receiver compared to transmitter) and up to 160 meters far from receiver antenna. The objects are street lights, traffic lights and signs, signboards and a big metallic object laid on the ground in front of one of the buildings. The contribution of each object to the received power depends to the object size, its angle toward transmitter and receiver antennas and its distances to them. The strongest scattered waves are arriving from a traffic light-sign close to the transmitter, a store signboard and the big metallic object on the ground which is also relatively close to the transmitter. In addition to signals scattered from these objects some other clusters are also identified but we have not been able to designate any visible object to them. This is because they are possibly multi reflected received paths or from a moving object.

Set B. This set includes only one scatterer with a direction of arrival equal to $72°$. However because the scatterer is very close to both receiver and transmitter it has a big impact on the receiving power. The object is a metallic plate attached to the side walk lattice.

Set C. This set includes a street light, a traffic light and a traffic sign. With direction of arrivals equal to $123°$ and $126°$ these scatterers have the most powerful influence on the received power. This is due to their close distance to the receiver antenna.

Set D. This set consists of multiple objects with directions of arrival from $150°$ to $180°$. These scatterer objects are signboards, street lights, traffic lights and traffic signs. The strongest scattered component among this set is one scattered by a big signboard above the rooftop of a building.

Set E. The three objects composing this set are a street radar pole, a traffic sign and traffic light poles. The direction of arrivals of the scattered waves from these objects are within $180°$ to $200°$ and their distance to the receiver antenna are relatively short. The radar pole and traffic sign are very close to the receiver antenna and therefore deliver a big amount of scattered power to the receiver.

Set F. This set has only one object that is a metallic handle very close to the receiver antenna and at with a direction of arrival of $231°$. It seems that it has a very strong effect because the object is located just 1 meter far from the receiver antenna.

Set G. This set is also including only one object that is a signboard attached to the street's wall in a distance of 6 meters from the receiver antenna with a direction of arrival equal to $249°$.

In addition to these scatterers, a number of received cluster waves have been detected which we have not been able to assign any visible object to them. This can be due to multi reflection effect. Table 3 also shows the residual powers. It is observable that 19% of the received power were scattered by these identified scatterers.

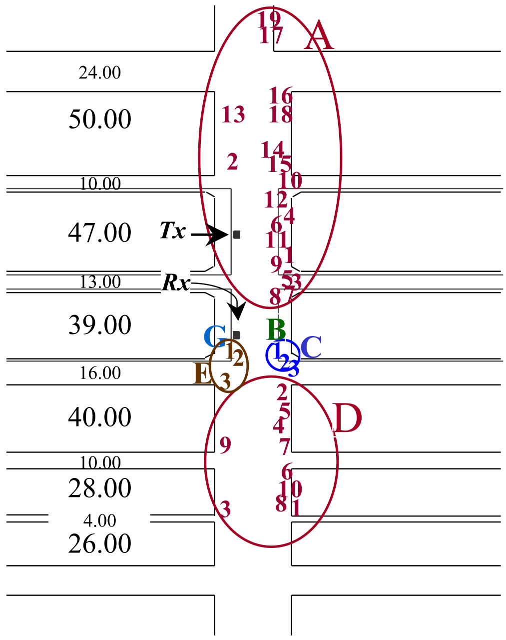

Figure 7　The distribution of identified scatterers.

5. Discussion

The results of section 4. makes it clear that the objects as small as 40×40 cm^2 traffic signs are a potential source of significant scattering in the urban microcell propagation channel. It also reveals that every traffic light and street light up to a distance of 200 meters from receiver or transmitter has a significant scattering impact in the received power. Every metallic object in the area seems to be involved in scattering transmitted signals to the receiver. The strength of any object's effect depends to its material, its size and shape, its surface angle to wavefront, its distance to the transmitter and receiver antenna and the overall structural configuration of the environment and the distribution of the objects in the microcell. Assuming single bounce we were able to identify a number of scatterer objects. The contribution of these objects to the received non-line-of-sight signals is 19% of the power. A larger amount of received signals were arriving in clusters, however we were not able to identify their scattering objects probably due to the one bounce assumption. These unidentified clusters deliver 56% of the received power.

6. Acknowledgement

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Table 3 Composition of the total received power.

Total Received Power	-50.2 dB
Power of LOS component	-51.4 dB
Power of identified scatterers component	-63.4 dB
Power of residual component (Contributed to the identified scatterers)	-57.1 dB
Ratio of the identified scattered power over the total scattered power	19%
Power of all clusters component	-58.8 dB
Power of residual component (Contributed to all clusters)	-59.8 dB
Ratio of the clusters power over the total scattered power	56%

Table 2 Identified scattering objects.

Set	No	Object Description	Rough Dimensions (m^2)	Contributed Loss (dB)	Excess Loss (dB)
A	1	Store signboard	4×1	80.1	18.3
	2	Traffic sign and light and its pole	0.6×0.6, 0.35×1, 6×0.3	81.3	14.8
	3	Street light pole	7×0.3	82.4	20.4
	4	Traffic light and its pole	0.35×1, 6×0.3	83.3	21.5
	5	A big metallic object on the ground	5×1.2	83.8	19.5
	6	Traffic sign $\times 2$	$(0.5 \times 0.4) \times 2$	84.6	21.5
	7	Signboard	0.8×0.8	85	23.6
	8	Traffic light pole	6×0.3	85.5	24.3
	9	Street light pole	7×0.3	86.1	24.9
	10	Traffic sign and light and its pole	0.4×0.4, 0.25×0.5, 6×0.3	86.9	20.4
	11	Traffic sign pole	8×0.4	88.4	26.4
	12	Traffic light pole	6×0.3	88.4	23.3
	13	Traffic sign	0.6×0.8	89.9	21.4
	14	Traffic sign	0.5×0.5	93.3	25.1
	15	Traffic sign	0.4×0.4	96	28.5
	16	Traffic sign $\times$ 2	$(0.5 \times 0.5) \times 2$	99.9	29.5
	17	Signboard (relatively far)	6×0.8	101.4	26.2
	18	Street light pole	7×0.3	103.3	33.4
	19	Signboard (relatively far)	6×0.8	104.6	29.6
B	1	A metallic plate attached to the sidewalk	0.6×1	85.2	23.4
C	1	Street light pole	7×0.3	86.2	22.7
	2	Traffic light pole	6×0.3	99.4	34.9
	3	Traffic sign	0.5×0.5	100.6	36.0
D	1	Over roof signboard	3×1.2	90.5	18.4
	2	Street radar pole	5×0.3	94.1	26.7
	3	Big traffic board	1.6×1.8	94.4	26.9
	4	Traffic sign and light and its pole	0.5×0.5, 0.35×1, 6×0.3	94.6	28.9
	5	Traffic sign	0.5×0.5	95.4	28.8
	6	Signboard	3×1	96.2	25.7
	7	Street light pole	7×0.3	96.5	27.2
	8	Traffic sign $\times 3$	$(0.5 \times 0.5) \times 2$, 0.4×0.4	99.5	27.7
	9	Traffic light and its pole	0.35×1, 6×0.3	100.4	31.2
	10	Store signboard	0.6×2.5	101.4	30.2
E	1	Street radar pole and traffic sign	5×3, 0.4×0.4	89.4	27.6
	2	Traffic light pole	6×0.3	93.6	31.0
	3	Traffic light pole	6×0.3	98.6	33.1
F	1	Metallic bar	1×0.1	90	29.3
G	1	Signboard	4×0.4	92.2	30.8