2GHz band experimental investigations of mobile communications over dense urban regions of India

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Abstract

The design of future generation mobile communication systems depend critically on the suitability of path loss prediction methods and their suitability to various regions. To investigate the radio channel behaviour experimental measurements in the 2GHz band were conducted in the dense urban regions of New Delhi for six GSM base stations. Path loss exponents have been deduced and observed results have been compared with existing prediction methods and their standard deviations have been presented.

1. Introduction

The introduction of cellular communication system in this country using both GSM and CDMA technologies has given a big thrust to mobile communication scenario. Recent reports indicate that in India mobile subscriber base crossed 200 million mark ranking this country fourth with China, US and Russia taking the first three positions. Projections indicate that by December 2007 this subscriber base may cross 250 million overtaking Russia[1]. In order to characterize the propagation characteristics in the 2 GHz band over different areas of the country an exhaustive radio measurements utilizing the existing cellular networks in urban, suburban and rural environments has been undertaken.

Many workers used propagation models where the mean path loss decays as a function of distance between the transmitter and receiver raised to power n where n is called path loss exponent [2] Vinko Erceg etal [3] developed a statistical pathloss/exponent model derived from 1.9GHz data collected in existing macrocells of US. Authors claim that it is applicable to different types of terrain (hilly/moderate to heavy tree density, hilly/light tree density, flat/light tree density), base station antenna heights from 0 to 80 m and base to terminal distances from 0.1 to 8 km. In the present study, radio measurements at 1800 MHz utilizing the Idea cellular network in various dense urban areas of Delhi and comparison of the observed values of path loss with various models has been carried out. Path loss exponents as a function of distance have been deduced.

2. Experimental details

The carrier signals of various GSM base station transmitters located in the dense urban/urban environments of New Delhi area operating in the 1.8 GHz belonging to Idea cellular network have been monitored with Nokia GSM receiver (model 6150) generally used as a drive-in tool for planning cellular network along with GPS receiver to know the latitude and longitude of the mobile. The sensitivity of receiver is -102 dBm. The base stations used in the present study are 1. Arunachal 2. Inner circle 3. Indra prastha extension (I.P.Extension) 4. Onkar nagar sector-1 5. Onkar nagar sector-2 6. Trinagar. All the six paths are situated in dense urban environment . The carrier levels are sampled 10times in a second. The details of the base stations are shown below in Table 1.

Table 1

Name of base station	Type of TX ant.	Gain Tx ant. (dBi)	Beamwidth Horiz (degree)	Beamwidth Verti (degree)	Height of tx ant. (m)
1 Arunachal	742212	17.5	65	7	32
2.Innercircle	739495	18.0	65	7	22
3.I.P.Extension	742212	17.5	65	7	27

4.Onkar nagar (Sec-1)	739495	18.0	65	7	24
5. Onkar nagar (Sec-2)	739495	18.0	65	7	24
6.Tri nagar	739495	18.0	65	7	24

Height of the mobile antenna = 1.5 m

3. Results

For all these base stations variation of observed path loss with distance, variation of path loss exponent and comparison of observed losses with existing prediction models have been carried out. But due to lack of space diagrams pertaining to Innercircle base station and Onkarnagar sec-2 base station representing typical variations have been included in the present paper and the results of remaining base stations have been described under standard deviations of prediction methods.

3.1 Inner circle base station

Figure 1 shows the scatterogram of observed path loss with distance for Inner circle base station. The base station is situated in a dense urban area and is in heart of New Delhi city. It is surrounded by multistory buildings. The observed values of path loss have been obtained for distances ranging from 50 m to 1.5 km. The diagram also contains curves corresponding to various path loss exponents n= 2,3,4,5. These curves represent the path losses deduced for the above exponents based on the logarithmic variation of path loss from the following equation

$$L = L_0 + 10\, n \log d \qquad (1)$$

Where L is the path loss deduced for various distances, L_0 is the path loss deduced at one metre and d is the distance in metres. In this case close to transmitter, high path losses of 150 to 170 dB have been observed. Predicted path loss curve corresponding to n=4 covers the majority of the observed points. Predicted curve with n=5 coincides with the observed values up to 400 m distance only. At distances close to the transmitter path loss exponents of the order of 7 are observed and then it falls steeply up to a value of 4 around 400 m and remains steady for the remaining distances.

Figure 2 shows the comparison of observed path losses with those of predicted from COST231 Hata method[4] and COST231 Walfish &Ikegami method [5]for building separation of 20,30 and 40 m and building heights of 15 and 18 m. WI method with heights of 18 m passes through majority of dense cluster of observed points at all distances. The same method with heights of 15 m shows the predicted loss less than that of 18 m and passes through some of the points. As the street width increases path loss decreases for a given building height. COST 231 Hata method under estimates the values by 10 to 20 dB. The variation in path loss for a given street width say 30m when building height changes from 15 to 18 m is 5.5 dB. Since there is a large data base of observed points, no attempt is made to draw average values of observed path loss.

3.2. Onkar nagar Sector-2 base station

Figure 3 shows the variation of observed path loss values with distance for Onkar nagar sec-2 base station. Curve for n= 4 passes through the majority of data points between 0.1-0.7 km. Curve for n = 5 corresponds to data points very close to transmitter and up to distances of 0.25 km. Curve for n = 3 corresponds to data points between 0.5 to 2.5 km. This becomes more evident when path loss exponents have been plotted as a function of distance. At distances close to transmitter exponent values fall from 6.5 to 3 at distances of 0.5 km and remains flat out around 3 for the remaining distances of 2.5 km. Figure 4 shows the comparison of observed path losses with that of COST 231 Hata & COST 231 WI method for building separation of 20 to 40 m and building heights of 15-18 m. All curves pass through large data cluster since there is a large scatter of data points close to transmitter. From 0.9 km onwards the predicted values overestimate the observed values.

3.3 Standard deviations of prediction methods

The mean prediction errors and the standard deviations of the prediction errors for COST 231 Hata, WI method for building separation of 20 m and building height of 15 m and measured regression line with respect to the observed values have been deduced as a function of distance for the above six base stations. Measured regression line exhibited lowest standard deviations ranging from 4 to 10 dB, COST 231 Hata method showed deviations from 7 to 24 dB and COST 231 WI method exhibited deviations from 7 to 26 dB. Mean prediction errors for all the three methods ranged from 2-4 dB, 2-30 dB and 2-27 dB respectively. Similar deviations for other building separation and building heights have been observed.

4.Discussion

At distances close to the transmitter due to high cluster of buildings probably line-of-sight (los) component could be missing. This might have lead to high path losses. As the mobile moves due to the availability of los component path losses decrease rapidly and remain flat with moderate variations for rest of the distances. In the case of Erceg etal also[3]who made extensive measurements at 1.9 GHz I New Jersey, Seattle and Chicago high path losses close to the transmitter were observed and then the loss was decreasing linearly with distance. In the present study the path loss is falling steeply up to 0.5 km. The propagation mechanism close to the transmitter is due to horizontal propagation and beyond 0.5 km it is due to vertical propagation. This also has been observed by Barbiroli[6]. The nature of variation of path loss exponent in the present study resembled to that of variation in Erceg etal's study. Steep transitions of path loss occur when the base station antenna height is close to the height of surrounding building roof tops. Hence the height accuracy of the base station antenna is especially significant if large prediction errors are to be avoided [7]

5. Conclusions

Narrowband signal level measurements were conducted in dense urban environments of New Delhi at 1800 MHz for six base stations. Observed path losses deduced from measurements were compared with COST 231 Hata and COST 231 W&I methods. Close to the transmitter high path losses were observed. They start falling steeply up to 500 m or so and there after they tend to remain flat. This has been exhibited by path loss exponents also. Close to the transmitter high path loss exponents of 6 to 7 were observed and fell steeply to 3-4 up to a distance of 500 m. This can be explained by means of horizontal and vertical propagation mechanisms. Till the break point the wave was traveling in the horizontal mode of propagation and after the break point vertical propagation assumed dominant role. Standard deviations of the prediction methods were deduced for all the base stations. All stations exhibited high values of deviations close to the transmitter and fell steeply from 500 m onwards. Measured regression line exhibits lower standard deviations compared with other prediction methods.. High path loss exponents observed close to the transmitter can force the operators to go for higher margins and in this context the study assumes importance for the design of future 3 G systems in this 1800 MHz band.

6. Acknowledgements

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7.References

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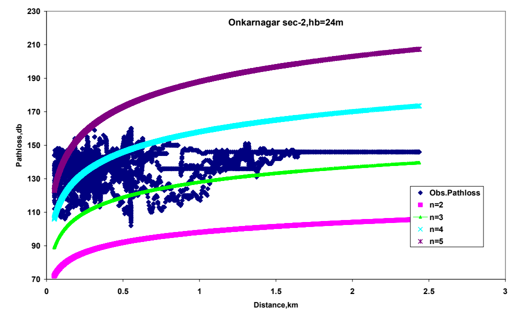

Fig 3: Observed path loss vs distance for Onkarnagar sec-2 base station

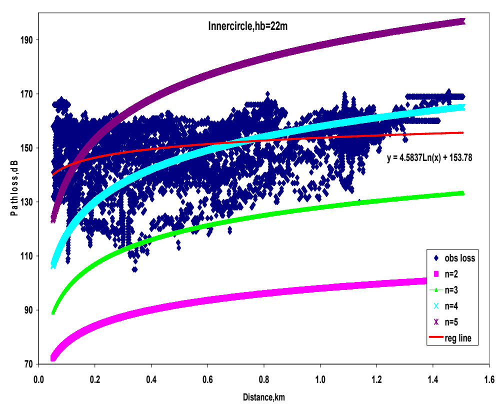

Fig1: Observed path loss vs distance for Inner circle base station

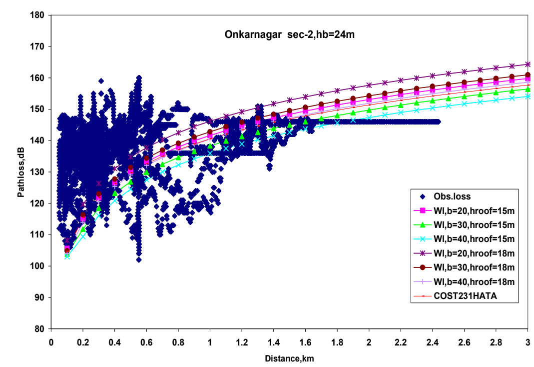

Fig 4: Comparison of observed path losses with various prediction methods for Onkarnagar sec2 base station

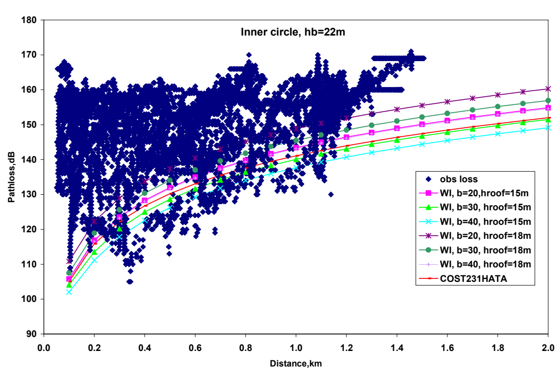

Fig 2: Comparison of observed path losses with various prediction methods for Inner circle base station