Mobile radio propagation path loss simulation for two districts of different buildings structures in Mosul-city

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Abstract— **In this paper two theoretical models have been considered for the prediction of path loss for two different districts in Mosul city, using MATLAB 7.4 program. The Walfisch-Ikegami (W-I) model for uniform heights and similar buildings in the Karama district . The other model is Okumura-Hata (OH) model applied for irregular and dissimilar buildings in the Almajmoa'a district. The information buildings heights are obtained from the civil Eng. Depart. in Mosul university. In this paper it can be shown that The effect of distance in regular area (karama) on path loss is about 10 dB larger than irregular area (Almajmoa'a), and The effect of varying antenna height in regular area (karama) on path loss is about 7 dB greater than irregular area (Almajmoa'a) for 40 meter variation.**

Keywords-component; propagation , pathloss ,cellular application .

I. INTRODUCTION

Since the nineties, a great progress is observed in wireless and mobile communications field . Mobiles make many tasks simple and easily to be accomplished. This requires imperatively good and accurate knowing and describing radio propagation for the intended area. Propagation of mobile radio signals is complex , and depending on the environment for which it has been shaped. In this paper the operating frequency is 2000MHz ,which is a standard of IMT2000 (International Mobile Telecommunications – 2000) and UMTS (Universal Mobile Telecommunications System)[1][2].

II. THEORETICAL ANALYSIS

P Propagation channel is a linear system defining a transformation between an input and an output signal, for best understanding the channel and overcome its eventual imperfections. In fact, signal affronts many distortions like e.g.: delays, spreading. These distortions are induced by various reflections that signal faces up during the Emission-Reception path. Consequently, other additive signals will be perceived by the receiver besides the main transmitted signal which must be captured in ideal situations. These additional signals have followed various and different paths. That's what is usually named: Multipath. With higher rates used in digital communications e.g., symbols have small duration in comparison with the delay spreading scale and a really superposition between them will be observed. Usually channel has many dimensions, giving a particular description as indicated in the fig. (1) [3] .

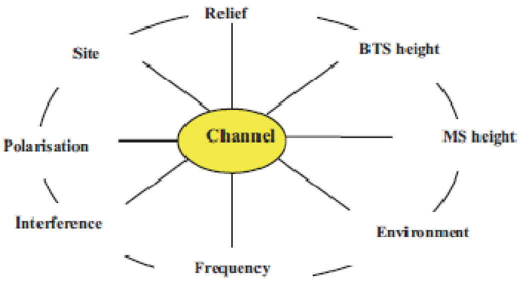

Fig. (1). Channel characterization versus different vision.

Parameters like antennas heights, frequency band, interference, polarization etc, and have an influence upon channel behavior are indicated above in the fig. 1. Direction and distance between reflectors (buildings, mountains, walls, cars) influe channel awkward and followed channel.

Method to model this channel are[3]:
- Statistical models ,like (Okumura-Hata) ,
- Physical Models ,like (Walfisch-Ikegami),
- Mixed Models,
- and References Models.

We study only the first two cases.

A - *Okumura-Hata Model (OH):*

This is an Empirical model, which is based on a Statistical Analysis of a great number of experimental measures that takes in account many parameters such as buildings, Base stations (BS) and Mobile stations heights[2][4]:

$$L\,(urban)(dB) = 46.3 + 33.9\,log(f_{MHz}) - 13.82\,\mathrm{LOG}(h_b)$$
$$-a(h_m) + (44.9 - 6.55\,\mathrm{LOG}(h_b))\,\mathrm{LOG}(d_{km}) \quad \ldots (1)$$

Where:
f_{MHz} operating frequency in MHz 1500 MHz -2000 MHz.
h_b the base station(BS)antenna height in meter 30m- 200m.
h_m the mobile(MS) antenna height in meter 1m – 10m .
d_{km} distance between BS and MS in km.

$a(h_m)$ the correction factor for mobile antenna height which is given by:

$$a(h_m)_{dB} = (1.1\log(f_{MHz}) - 0.7)h_m - 1.56\log(f_{MHz}) - 0.8 \quad \text{....(2)}$$

Equation (1) is an extension version of original Hata model to work up to 2GHz by The European comparative for scientific and technical research (EURO-COST) [5].

B- Walfisch-Ikegami Model (W-I)

This model is based on regular area which have rows of buildings, which are nearly of equal and uniform height and are located on flat terrain. The building are organized along the street grid with little or no side-to-side spacing and nearly equal front-to-front and back-to-back spacing. The propagation takes place primarily over building [1]. The model considers the impact on rooftops and building heights using diffraction to predict average signal strength at street level . The model consider the path loss (L) to be the product of three factors [2] :

- Free space loss.
- Losses added by diffraction.
- Losses introduced by rooftops near the studied area.

Fig. (2) illustrate the geometry used in the walfisch model .

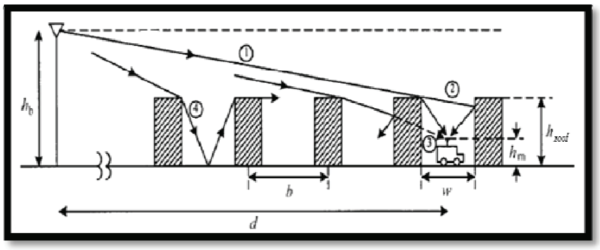

Fig. (2) propagation geometry for model by Walfisch – Ikegami.

From fig. (2) it can be noted that the signals arrive at the receiver from the diffraction from the 1st ,2nd and 3rd as if the model show that the signals travels from rooftops.

This model depends on:

1- The height of the buildings.
2- The width of the streets and the width of the buildings.
3- The distance between buildings.
4- The orientation of the streets relative to the line of sight (LOS) and non line of sight (NLOS).
5- The distance between the TX and receiver the height of TX and RX antenna and the frequency.

COST 231 Walfisch–Ikegami (WI) model [1] is the most widely used empirical model today, being an extension of the models from J. Walfisch and F. Ikegami. to work up to 2GHz by The European comparative for scientific and technical research (EURO-COST). It has been adopted as a standard model for 3G IMT 2000/UMTS systems [5]. It is valid within the following constraints.

- BS height : 4–50m.
- MS height : 1–3m.
- BS to MS separation : 0.02–5 km.

The Walfisch – Ikegami equation is given by:

$$L = L_O + L_{rts} + L_{msd} \quad \text{...(3)}$$

Where :

L_O= free space loss.

L_{rts}= rooftop to street diffraction and scatter loss.

L_{msd}= multi screen diffraction loss due to the rows of building .

$$L_o = 32.4 + 20\log d_{km} + 20\, log f_{MHz} \quad \text{...(4)}$$

$$L_{rts} = -16.9 - 10\log w + 10 log f_{MHz} + 20\log(h_{roof} - h_m) - L_{ori} \quad \text{...(5)}$$

Where :

h_{roof} : The height of the buildings.

$$L_{ori} = \begin{cases} -10 + 0.354\dfrac{\varphi}{\deg} & \text{for } 0^0 \le \varphi < 35^0 \\ 2.5 + 0.075(\dfrac{\varphi}{\deg} - 35) & \text{for } 35^0 \le \varphi < 55^0 \\ 4.0 - 0.114(\dfrac{\varphi}{\deg} - 55) & \text{for } 55^0 \le \varphi < 90^0 \end{cases} \quad \text{..(6)}$$

φ is the angle between incident wave and street oriented .

$$L_{msd} = L_{bsh} + k_a + k_d\log(d_{Km}) + k_f\log(f_{MHz}) - 9\log(b) \quad \text{..(7)}$$

Where b The distance between buildings.

$$L_{bsh} = \begin{cases} -18\,Log\,[1 + (h_b - h_{Roof})] & \text{for } h_b > h_{Roof} \\ 0 & \text{for } h_b \le h_{Roof} \end{cases} \quad \text{...(8)}$$

$$k_a = \begin{cases} 54 & h_b > h_{Roof} \\ 54 - 0.8(h_b - h_{Roof}) & \text{d} > 0.5 \text{ km and } h_b \le h_{Roof} \\ 54 - 0.8(h_b - h_{Roof})\dfrac{d_{Km}}{0.5} & \text{d} < 0.5 \text{ km and } h_b \le h_{Roof} \end{cases} \quad \text{..(9)}$$

$$k_d = \begin{cases} 18 & \text{for } h_b > h_{Roof} \\ 18 - 15\dfrac{(h_b - h_{Roof})}{h_{Roof}} & \text{for } h_b \le h_{Roof} \end{cases} \quad \text{..(10)}$$

$$k_f = -4 + 1.5\left(\frac{f_{MHz}}{925} - 1\right) \quad \text{....(11)}$$

The term k_a represents the increase in path loss when the base station antenna is below rooftop height. k_d and k_f allow for the dependence of the diffraction loss on range and frequency ,respectively .

III. RADIO NETWORK PLANNING SIMULATION FOR TWO DIFFRENT REGIONS.

For Mosul city shown in fig. (3), two regions have been investigated, first is the Almajmoa'a region, and second is the Karama region. Usually the OH model used by mobile companies in all Mosul city because it is assumed irregular region, but regular region can be seen in Karama district (building structure is nearly equal), W-I propagation model is applicable to district of uniform area buildings, which is appropriate for Karama region .

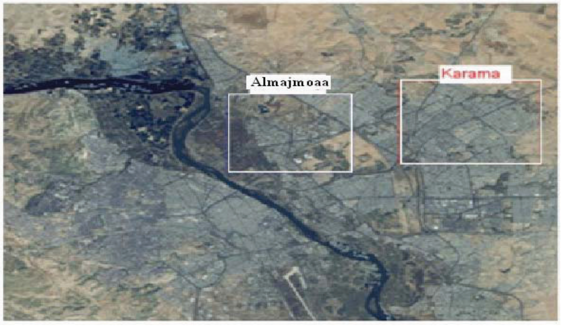

Fig. (3) Mosul city.

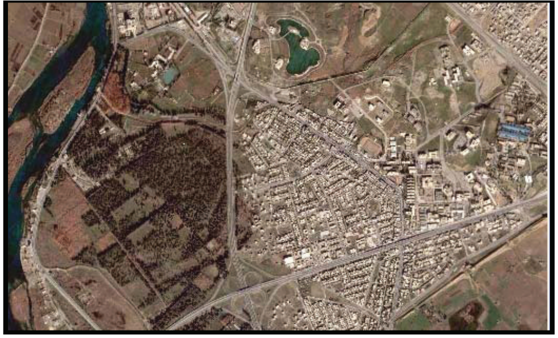

Fig. (4) Almajmoa'a region in Mosul city.

Fig. (5) Karama region in Mosul city.

a) *Path loss study for Almajmoa'a region using Okumura-Hata Model*:

In Almajmoa'a region shown in fig. (4), all buildings are irregular and not of uniform shape, for these reasons W-I model can't be applied but OH is more suitable.

- Simulations for *OH Model* in Almajmoa'a:

i. Study of coverage range in OH model:

For operation frequency of 2000MHz,1.5m mobile antenna height and 25m base station antenna height , Fig. (6) shows the variation of path loss with distance, which shows that as the coverage of cell increases the path loss increases .

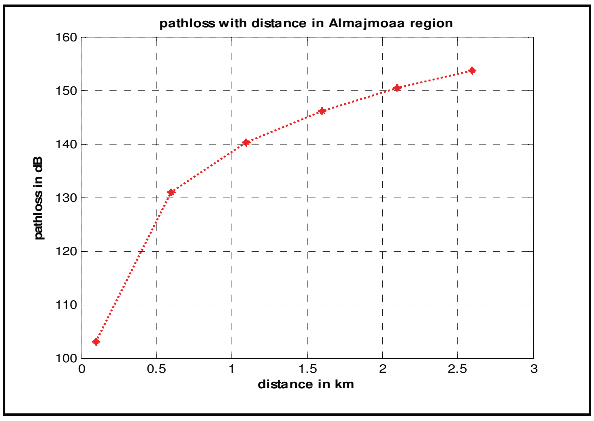

Fig. (6) : path loss versus distance for O-H in Almajmoa'a region.

ii. Study of BS height in OH model :

Fig. (7) shows the variation of path loss with distance for four BSs height (30m,50m,70m and 100m) , which shows that as the BS height increases, path loss decreases.

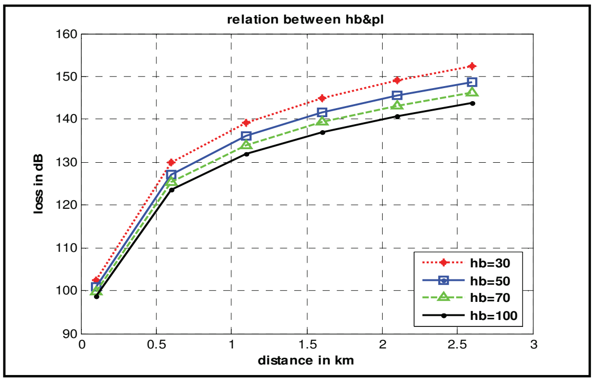

Fig.(7) : path loss versus distance for four BS heights in OH model.

b) *Path loss study for karama region using Walfisch-Ikegami (W-I) model*.

In karama region shown in fig. (5), buildings are regular and of uniform shape, for these reasons W-I model can be applied. (karama's information which is used in simulation, are given from **civil Eng**. Depart. in Mosul university).

- Simulations for W-I in karama:

1- Study of coverage range in W-I model:

Buildings in this region have 3 floor with 3 m height for each floor ,i.e. the whole building's height (hroof) is 9m . Base station's height (hb) is 25m . buildings distance (b) are 6m , street width (w) is 4m , operating frequency 2000MHz , mobile antenna's height (hm) is 1.5 m . Fig. (8) shows the relation between path loss and distance in Karama district with W-I model ,this figure show that as the coverage of cell increases the path loss increases in mobile unit at cell boarder.

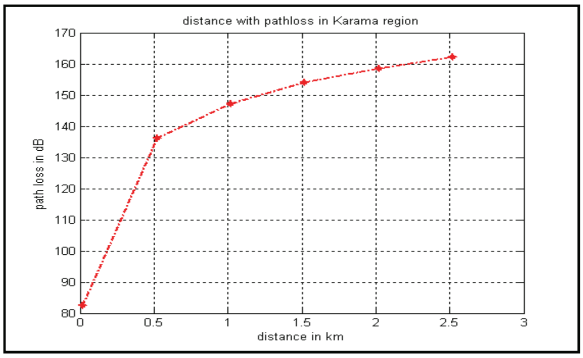

Fig. (8) path loss versus distance for W-I in Karama.

2- Study of BS height in W-I model

Fig. (9) shows the variation of path loss with distance for three BSs height (hb=25m>hroof , hb=9m= hroof & hb=5m<hroof) this figure shows that to reduce the path loss they must increase BS height to become higher than buildings height, to avoid reflection from buildings .

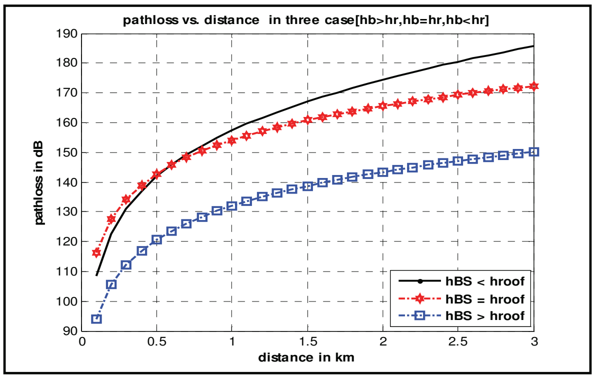

Fig. (9) path loss versus distance for different BS heights.

IV. RESULTS :

The simulation results of the two different districts considered are shown in fig.(10) (for same BS and MS antenna height and same operating frequency),which shows that karama region using W-I model have larger path loss than Almajmoa'a region using OH model about 7 -10dB , because of rooftop and multi-screen effects in karama region which makes more diffraction for signal.

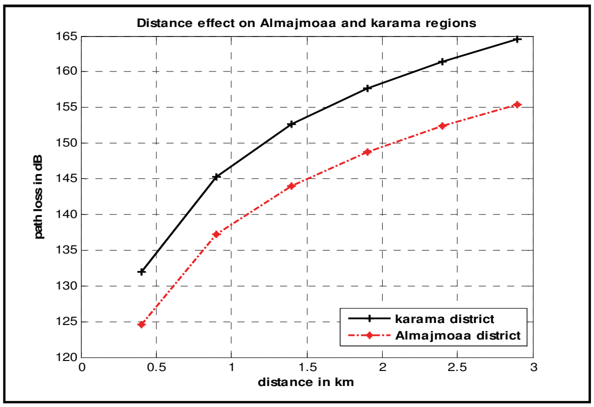

Fig. (10) path loss versus distance in karama and Almajmoa'a regions.

The path loss verses base stations height for OH model and W-I model are shown in fig.(11) , which shows that the path loss verses BS antenna height in karama district is higher than that for Almajmoa'a district, which can be attributed to high signal diffraction on roof top in karama region , and this fig. shows that the decrease path loss in karama region greater than that in Almajmoa'a region by 7dB, due to the signals in karama region are release from rooftop and multi-screen effects for increasing BS height over the rooftop of karama regular buildings .

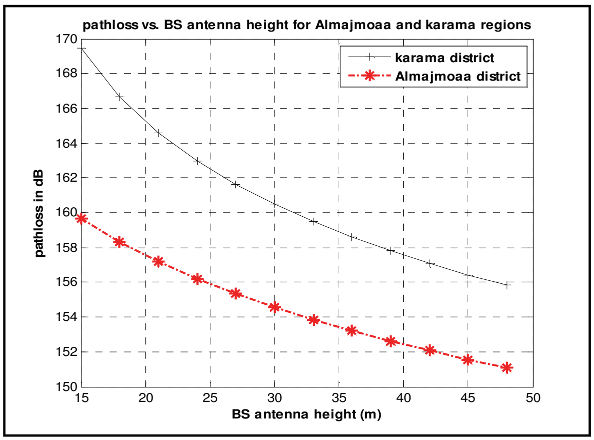

Fig. (11) path loss versus BS antenna height .

V. CONCLUSION

In this paper two districts in Mosul city were investigated ,one (Karama district) which has large number of similar and uniform building, Walfisch-Ikegami model is used which is suitable for radio network planning. The other is the Almajmoa'a district which has dissimilar and irregular building and less buildings density than Karama, Okumura-Hata model is applicable. In this paper the following point are concluded:

- The effect of distance in regular area (karama) on path loss is about 10 dB larger than irregular area (Almajmoa'a) as shown in fig.(10) .
- The effect of varying antenna height in regular area (karama) on path loss is about 7 dB greater than irregular area (Almajmoa'a) for 40 meter variation as shown in fig.(11).

VI. REFERENCES

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