IMPACT OF BUILDING ON THE PERFORMANCE OF WIMAX COMMUNICATION SYSTEM

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Outlines

- What is WiMAX
- Competing Technology
- WiMAX Architecture
- WiMAX IEEE Standard
- Suggested Propagation Model
- Simulation Results
- Conclusions

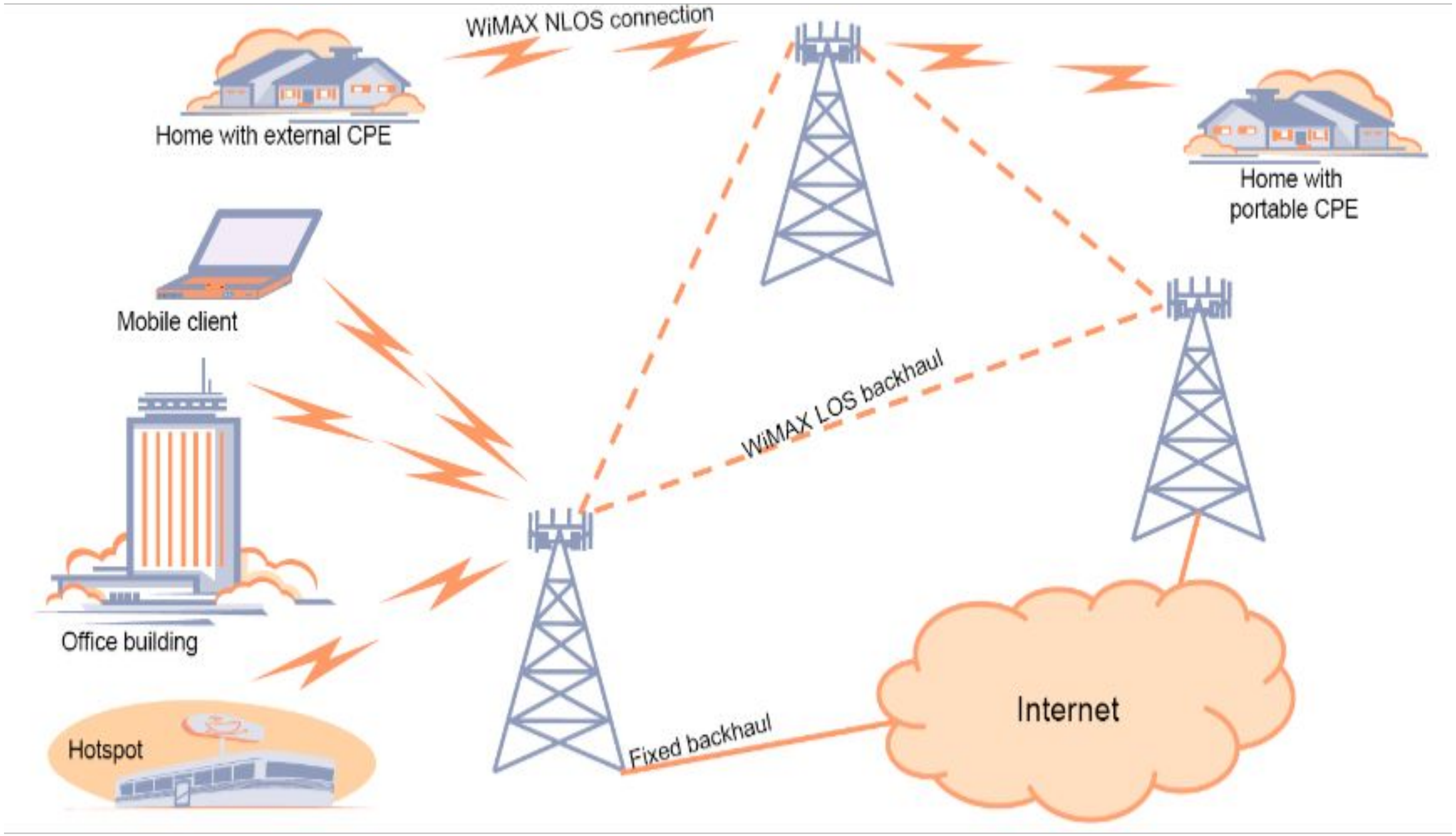
What is WiMAX?

- WiMAX stands for Worldwide Interoperability for Microwave Access.
- A Broadband Wireless Access(BWA) technique offering fast broadband connection.
- A fourth generation (4G) technology.
- Based on IEEE 802.16 standard.
- A wireless communications standard designed for creating Metropolitan Area Networks(MANs).
- IP based
- performance similar to Wi-Fi, with the coverage and QOS (quality of service) of cellular networks.

COMPETING TECHNOLOGY

Parameters	WiMax	Wi-Fi	3G
Frequency	2 - 11 GHz	2.4 GHz	1700-2100 MHz
Range	~31 miles	~100 m	Varies
Data Transfer Rate	70mbps	11 ~ 55mbps	1-14mbps
Users	1000s +	> 10	10,000+

WiMAX Architecture



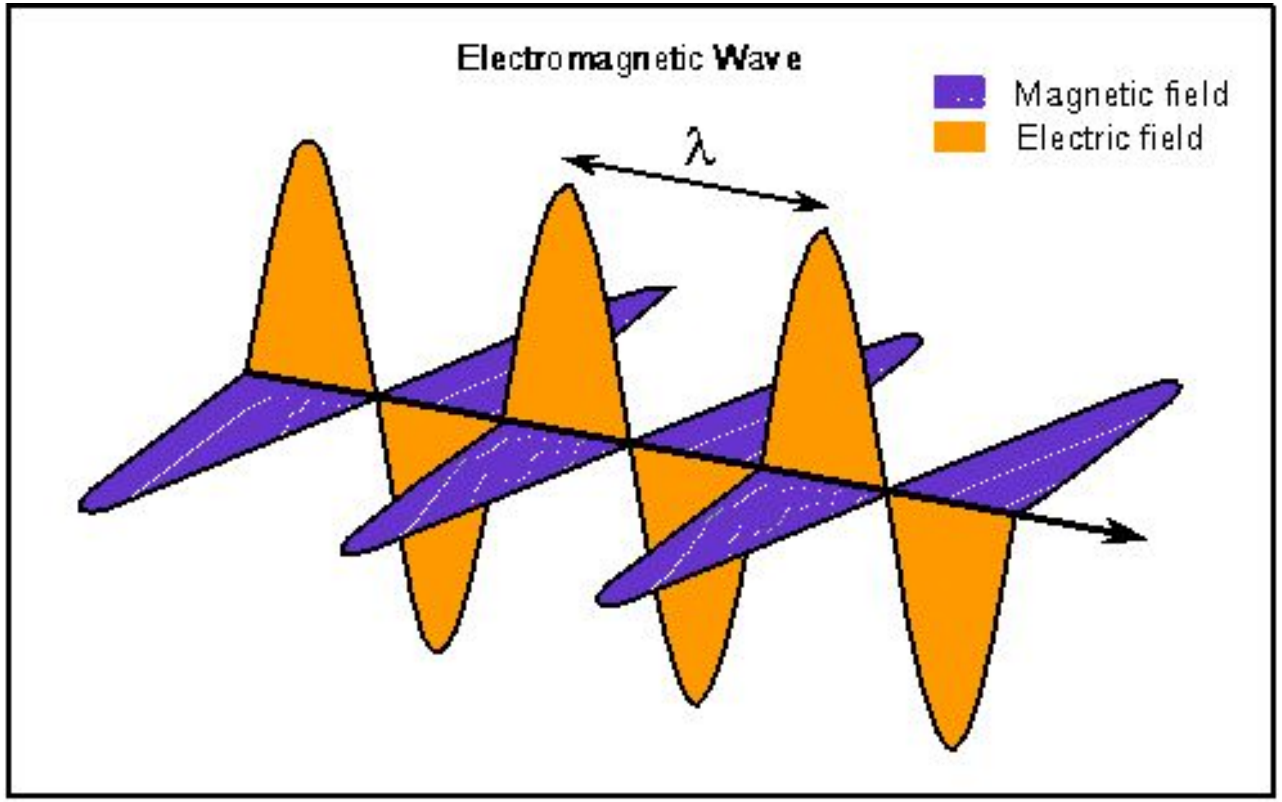
WiMAX IEEE Standard

802.16 STANDARDS

	IEEE 802.16	IEEE 802.16a/802.16d	IEEE 802.16e
Completed	Dec 2001	Oct 2004	Dec 2005
Spectrum	10 - 66 GHz	2 – 11 GHz	2 - 6GHz
Application	Backhaul	Wireless DSL and Backhaul	Mobile Internet
Channel Conditions	Line of Sight Only	Non-Line of Sight	Non-Line of Sight
Bit Rate	32 – 134 Mbps	Up to 75 Mbps	Up to 15 Mbps
Modulation	QPSK,16QAM and 64QAM	OFDM ,QPSK,16QAM, 64QAM	OFDMA
Channel Bandwidths	20,25 and 28 MHz	1.5 and 20 MHZ	Same as 802.16d

Suggested Propagation Model Assumptions

1. An Omni dimensional base station antenna radiated a spherical waves.
2. Base station antenna radiates the signal of frequency 2.3GHz.
3. The values of conductivity are 0.005 S/m, 0.092 S/m for ground and building, respectively
4. The relative permittivity is 15, 5.5 for ground and building, respectively



Suggested Propagation Model

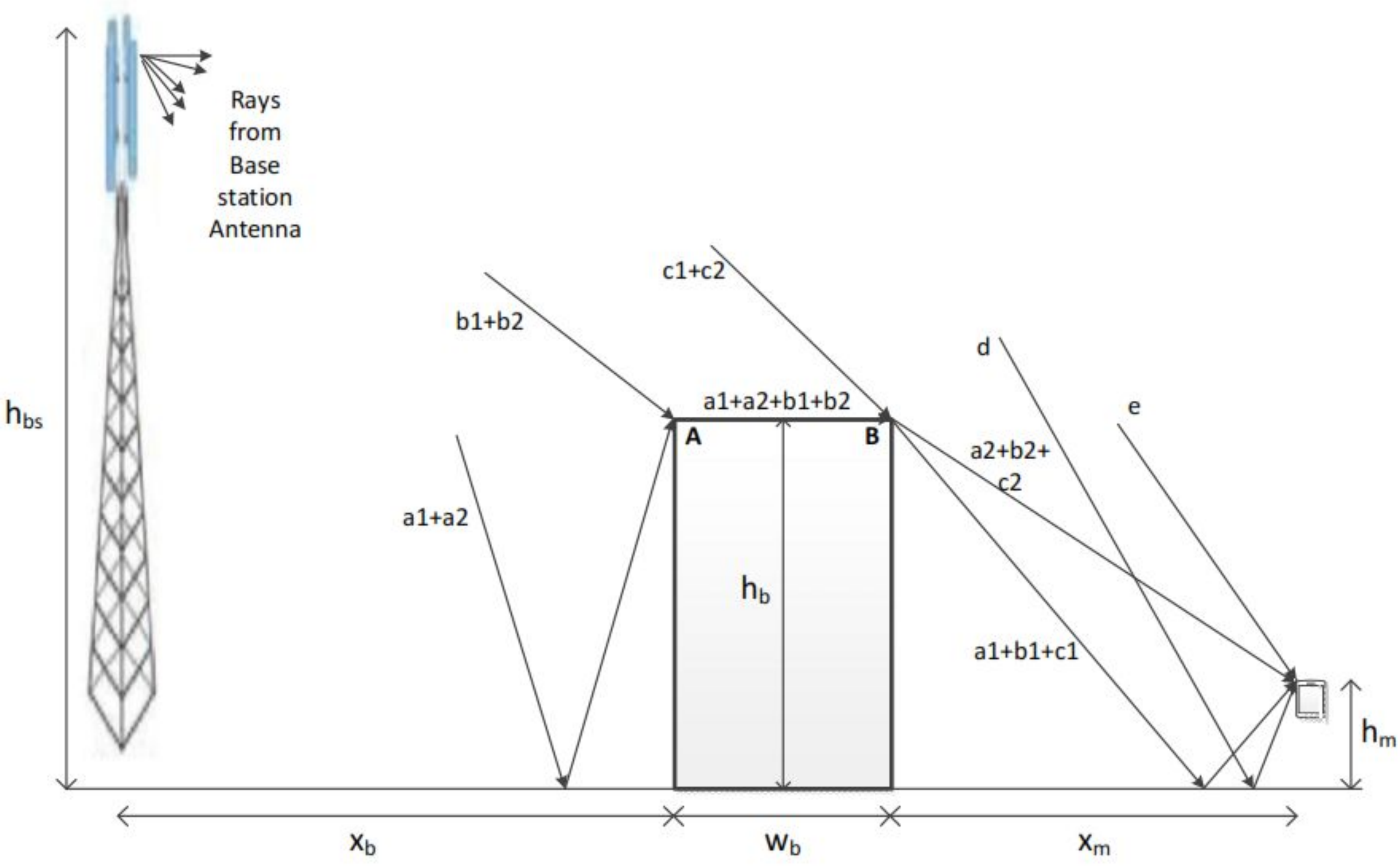
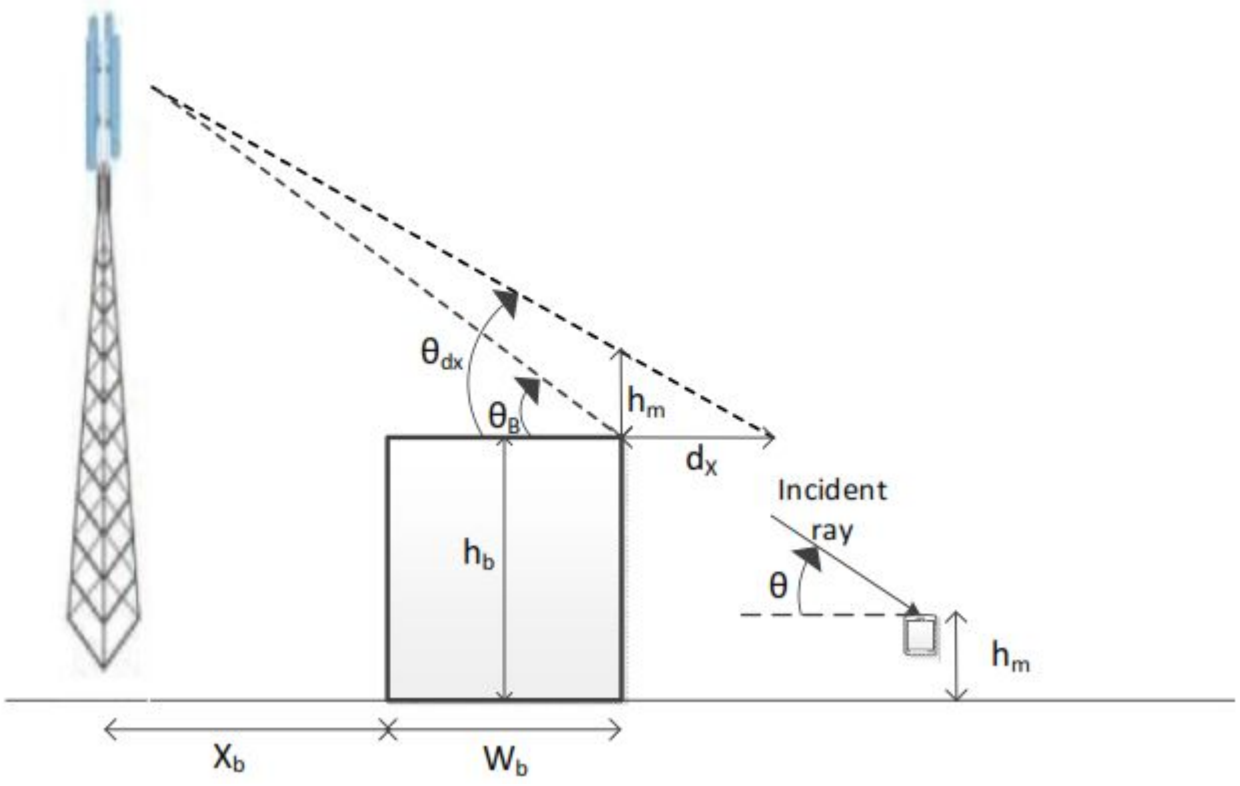


Figure 1. Propagation model: different received ray contributions at mobile



θ:Elevation angle of incident ray.
θ_B:Minimum angle at which a direct ray is seen by the mobile.
θ_{dx}:Minimum angle at which a reflected ray is seen by the mobile.

1) $\theta_B \leq \theta$, the mobile receives total rays ofa1, a2, b1, b2, c1and c2.
2) $\theta_{dx} \leq \theta < \theta_B$, the mobile receives total rays of a1, a2, b1, b2, c1, c2 and d.
3) $\theta < \theta_{dx}$, the mobile receives total rays of a1, a2, b1, b2, c1, c2, d and e.

a1) Ground reflection then second order diffraction then ground reflection.

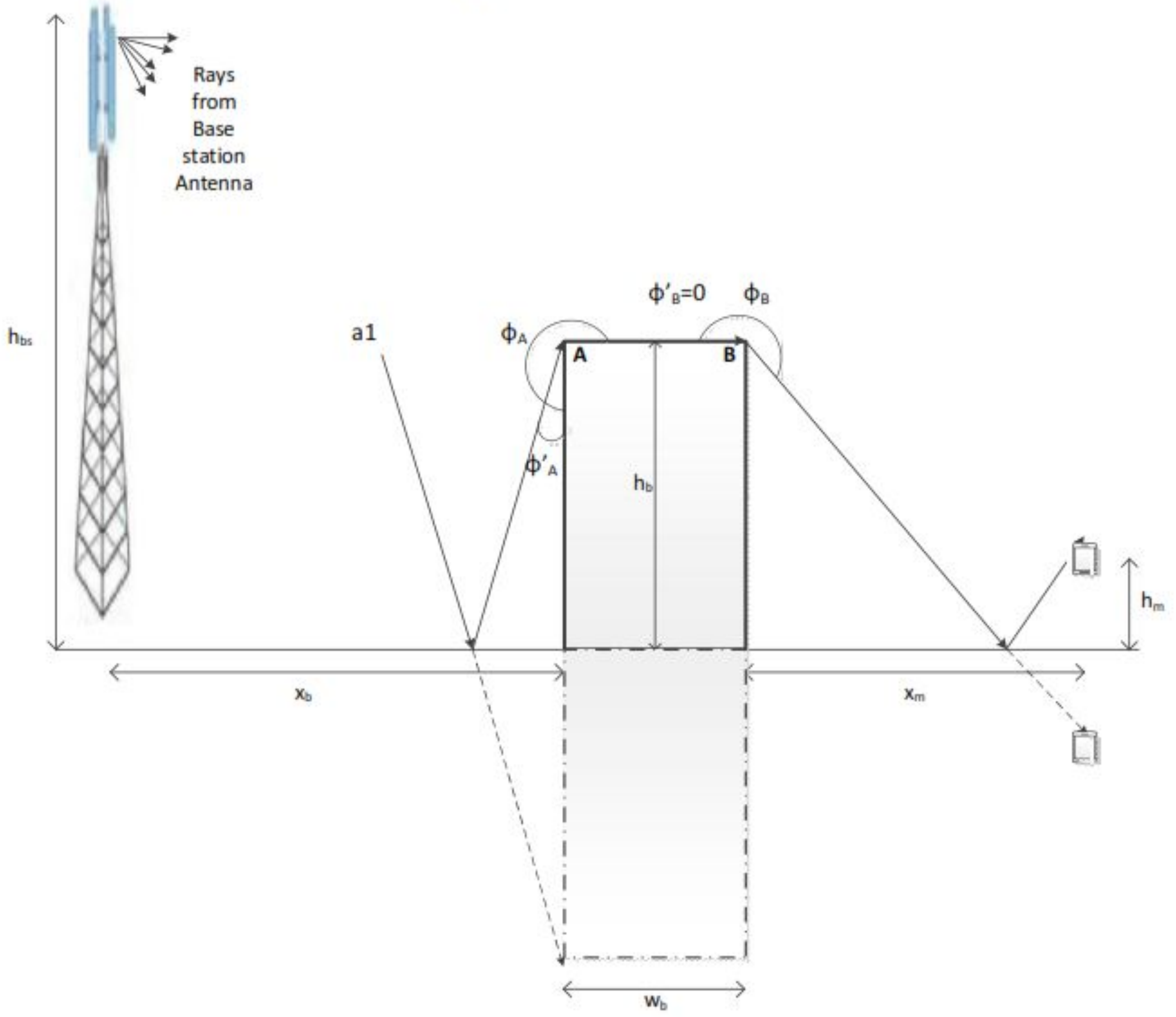


Figure 3. Formulation of ray a1

$$E_1^i = E_0 \frac{e^{-jks_T}}{s_T} \Gamma^s \left(\frac{\pi}{2} - \tan^{-1}\left(\frac{h_{bs}+h_b}{x_b}\right)\right) \Gamma^s \left(\frac{\pi}{2} - \tan^{-1}\left(\frac{h_{bs}+h_m}{x_m}\right)\right) D_A^s D_B^s \ldots (4)$$

$$H_1^i = H_0 \frac{e^{-jks_T}}{s_T} \Gamma^h \left(\frac{\pi}{2} - \tan^{-1}\left(\frac{h_{bs}+h_b}{x_b}\right)\right) \Gamma^h \left(\frac{\pi}{2} - \tan^{-1}\left(\frac{h_{bs}+h_m}{x_m}\right)\right) D_A^h D_B^h \sqrt{\frac{s_T}{s_1 s_2 s_3}} \ldots (5)$$

$$s_{T=}\ s_1 + s_2 + s_3 \ldots (6)$$

$$s_1 = \sqrt{(h_{bs} + h_b)^2 + (x_b)^2} \ldots (7)$$

$$s_{2=w_b} \cdots (8)$$

$$s_3 = \sqrt{(h_b + h_m)^2 + (x_m)^2} \ldots (9)$$

$$\acute{\emptyset}_A = \frac{\pi}{2} - \tan^{-1}\left(\frac{h_{bs}+h_b}{x_b}\right) \ldots (10)$$

$$\emptyset_A = \frac{3\pi}{2} \ldots (11)$$

$$\acute{\emptyset}_B = 0 \ldots (12)$$

$$\emptyset_B = \frac{3\pi}{2} - \tan^{-1}\left(\frac{x_m}{h_b+h_m}\right) \ldots (13)$$

Simulation Results

Table 1. Simulation Parameters

Parameters	Urban	Suburban	Rural
Base station antenna height	30 m	30 m	20 m
Mobile antenna height	1.5 m, 3 m	1.5 m, 3 m	1.5 m, 3m
Horizontal distance between the base station and the building	50 m,100 m	50 m,100 m	50 m,100 m
Building height	15 m	12 m	6 m
Building Width	10 m	8 m	4 m

- Normalized signal level Vs. Mobile distance
- CDF & PDF

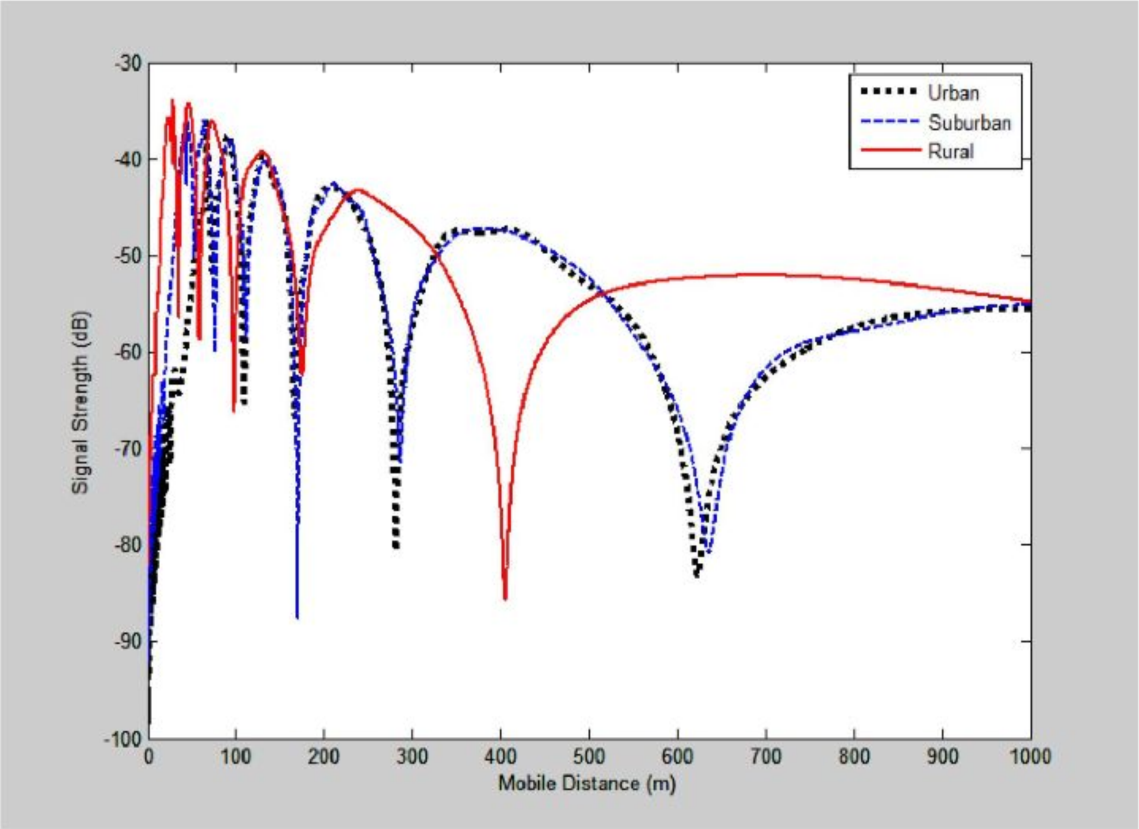


Figure 4. Normalized signal strength for soft polarization signal at x_b=50, h_m=1.5 in urban, suburban, rural environments

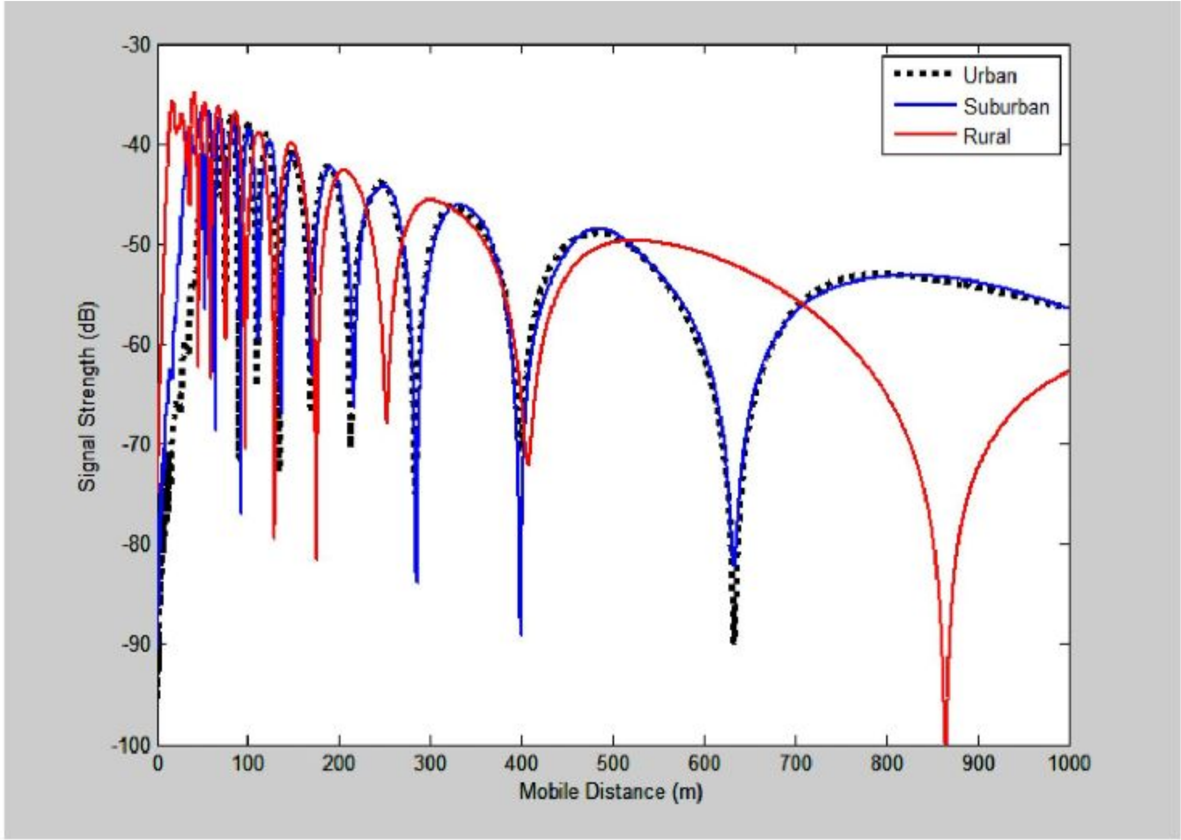


Figure 5. Normalized signal strength for soft polarization signal at x_b=50m, h_m=3m in urban, suburban, rural environments

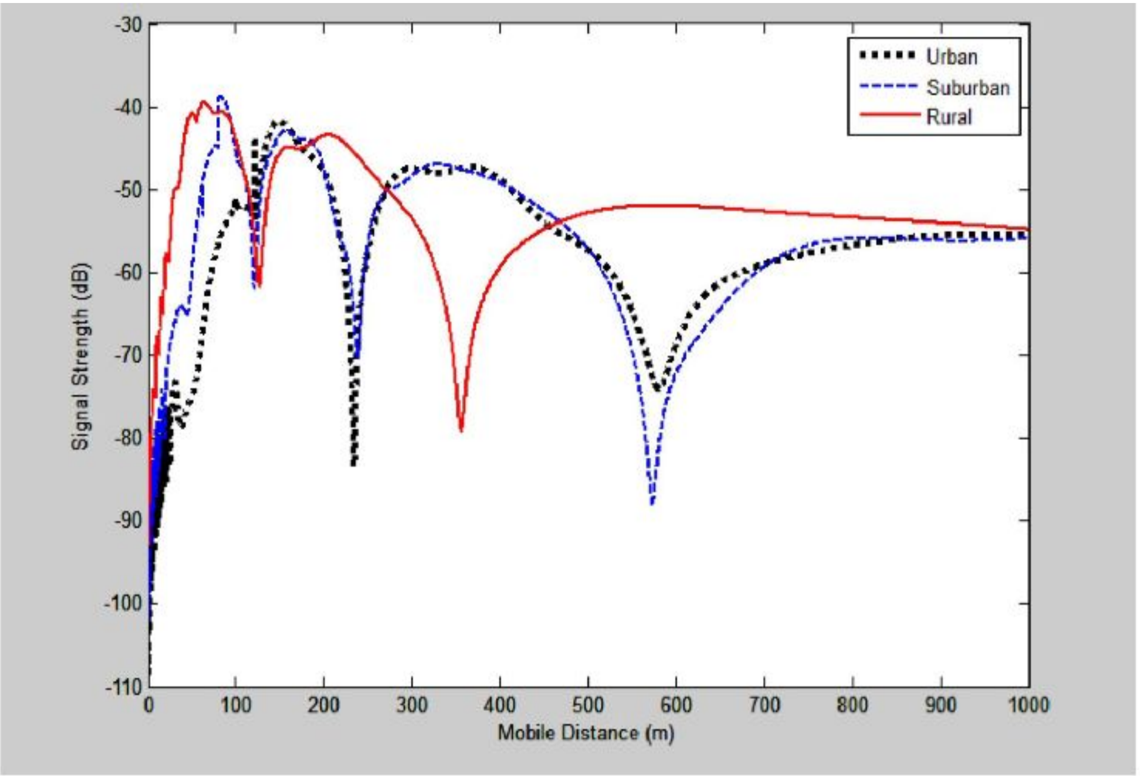


Figure 6. Normalized signal strength for soft polarization signal at x_b=100m, h_m=1.5m in urban, suburban, rural environments

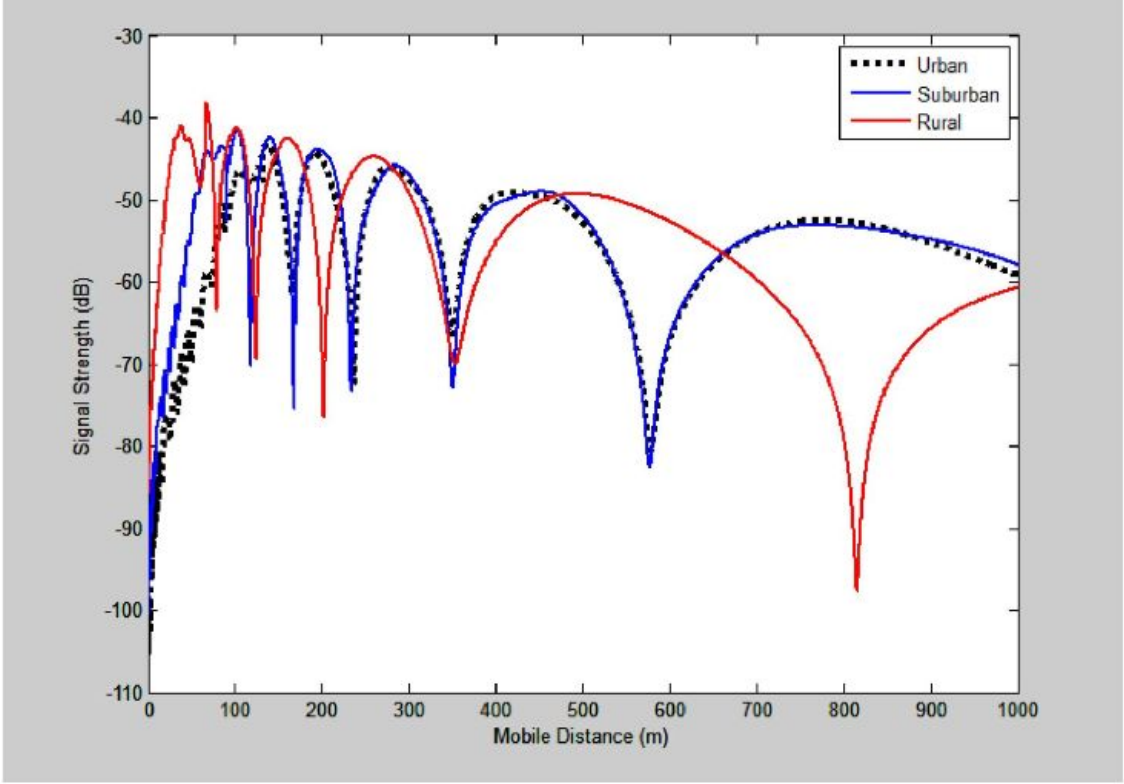


Figure 7. Normalized signal strength for soft polarization signal at x_b=100m, h_m=3m in urban, suburban, rural environments

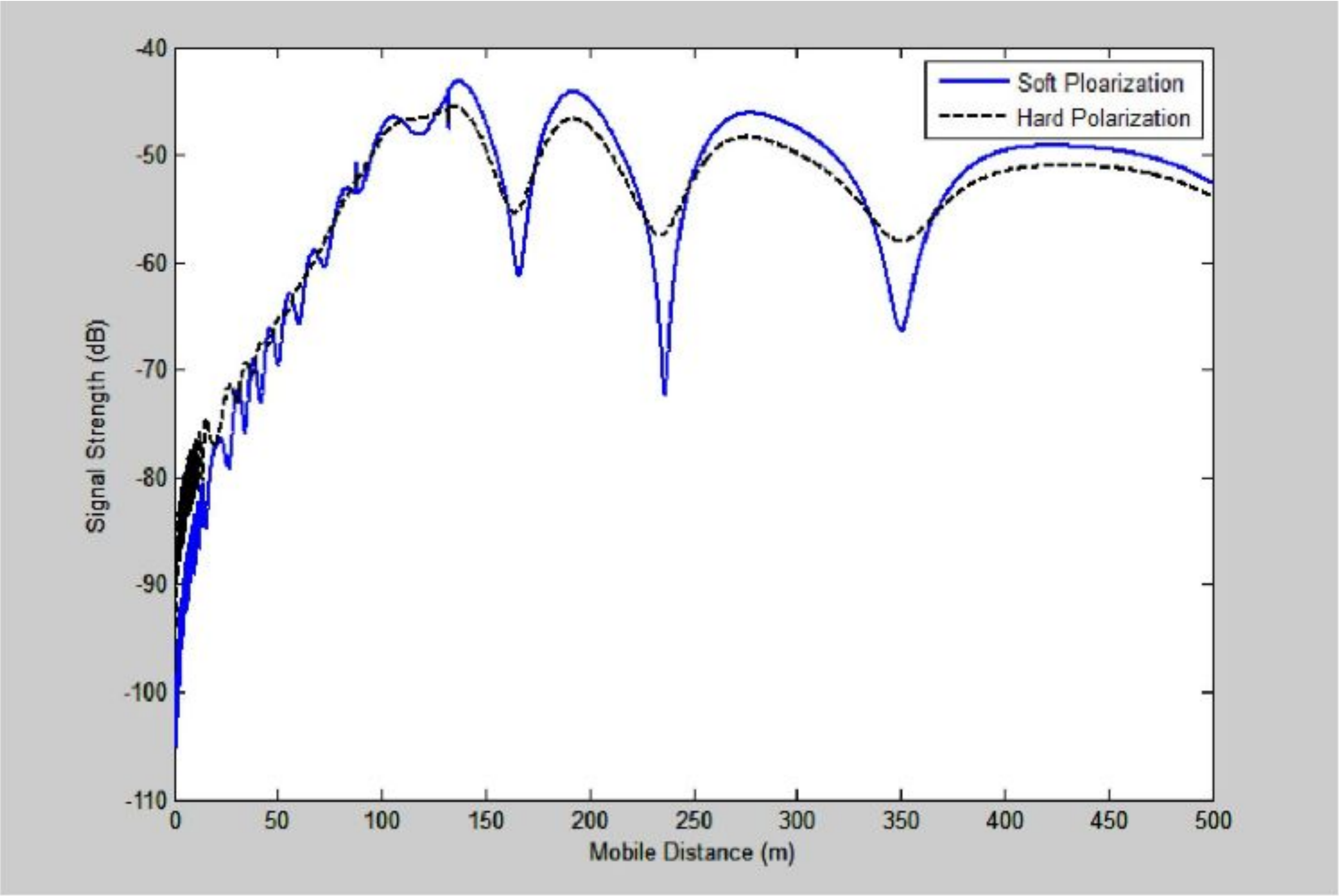
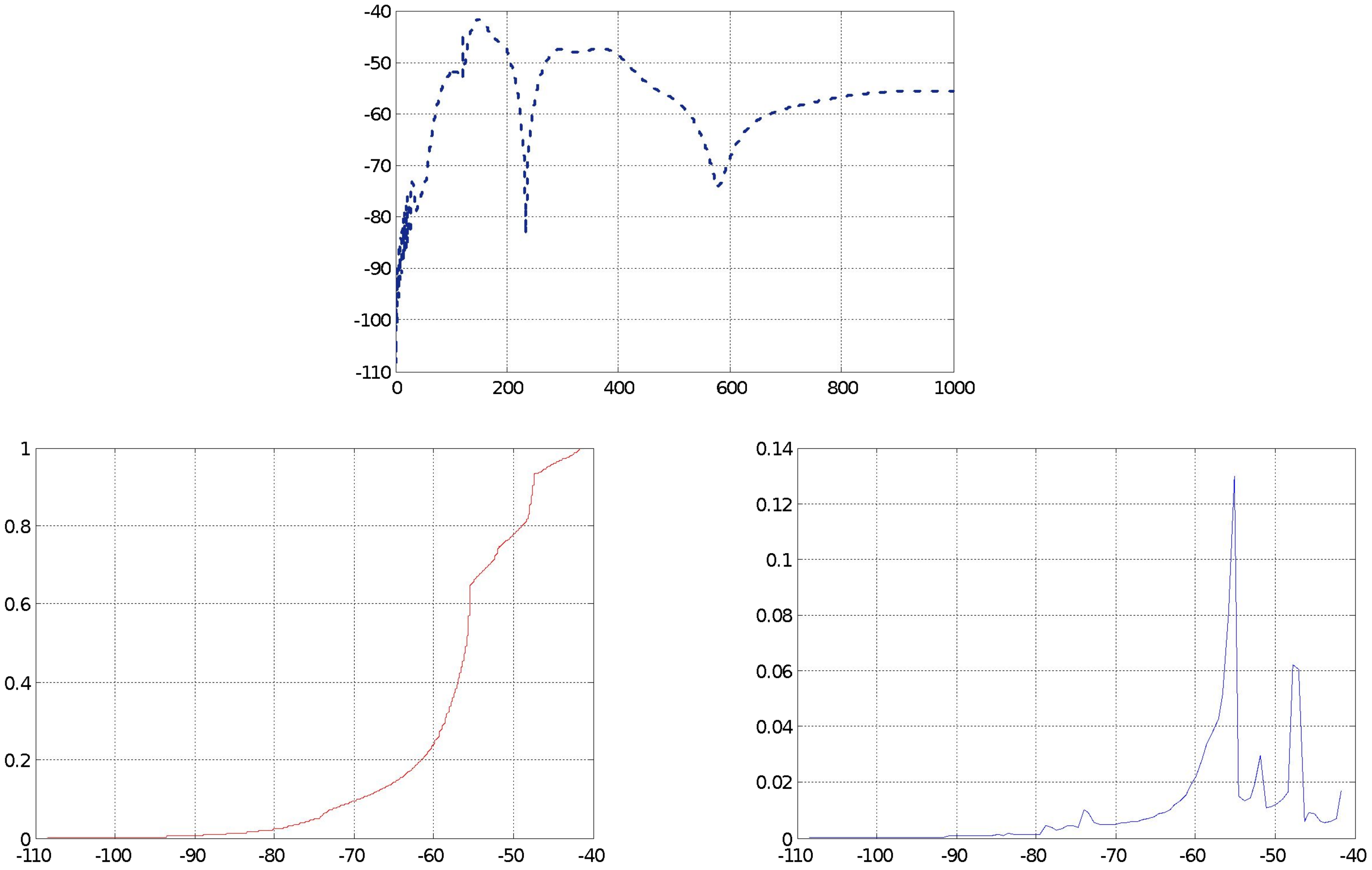


Figure 8. Normalized signal strength for soft polarization and hard polarization signal at x_b=100m, h_m=3m


-40
-50
-60
-70
-80
-90
-100
-110
0
200
400
600
800
1000
1
0.8
0.6
0.4
0.2
0
-110
-100
-90
-80
-70
-60
-50
-40
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-110
-100
-90
-80
-70
-60
-50
-40

Conclusions

- The propagation model in cellular WiMAX considers the base station radiates a signal
- that reaching the mobile in multipath channel with the presence of lossy building blockage.
- The signal analysis was performed using ray tracing techniques and the uniform theory of diffraction (UTD).
- The signal available at the mobile antenna is the result of a direct ray in addition to other reflected and diffracted rays induced by the two roof edges and surfaces of a building and the ground.
- Each ray contribution is formulated by a mathematical equation.
- The received horizontal and vertical signal levels are calculated versus the mobile distance where the mobile was moving behind the building in reverse direction of base station.
- The results computed in typical building dimensions in urban, suburban and rural areas were considered.