

Base Station Location Optimization with UTD and GO Models

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Abstract: - Providing threshold signal quality is the most important problem in wireless communication for indoor and outdoor applications. Coverage mapping is required to deploy the base station to optimum place in order to ensure threshold value. Optimization of base station location is very important to communicate reliably, efficiently and healthy. Coverage is predicted by Uniform Theory of Diffraction (UTD) and geometrical optic (GO) models. By optimization, less number and power base station will be used. In this study, coverage maps are generated in all transmitter position and then optimum base station location is determined with using this coverage maps.

Key-Words: - Optimization, Coverage mapping; UTD; diffraction; wave propagation; path loss.

1 Introduction

Coverage prediction is significant to install reliable and efficient wireless communication systems for indoor and outdoor applications like Bluetooth, access point, DECT or GSM. To provide the threshold electric field strength, base stations have to be deployed after coverage prediction done. In free space communication coverage prediction could be done by calculating electric field strength with Geometrical optic model. In contrast, in urban case Uniform theory of diffraction (UTD) model [1] have to be used. Because GO model cannot explain diffraction [2]. UTD model, a rapid high frequency model, is introduced in order to solve diffraction problem of electric field behind an obstacle. Optimum base station locations are required in order to reduce base station number and increase QoS of broadcasting systems. Optimization of location of base station can be determined by extracting coverage map as in radio planning tool like FEKO [3] and ACCURA [4]. Ray-tracing is important to obtain more accurate coverage maps and determine optimum base station location [5-8]. All the direct, reflected and diffracted waves can be determined by ray tracing technique. In the rest of paper, brief information about ray tracing technique, UTD and GO models is given, then a coverage prediction simulation and optimum base station simulation are carried out and finally conclusion section is given.

2 Ray Tracing Techniques

In order to calculate the field strength at a point accurately all the ray contributions have to be determined. These rays can be direct, reflected or diffracted rays as shown in Fig.1 (a, b, c).

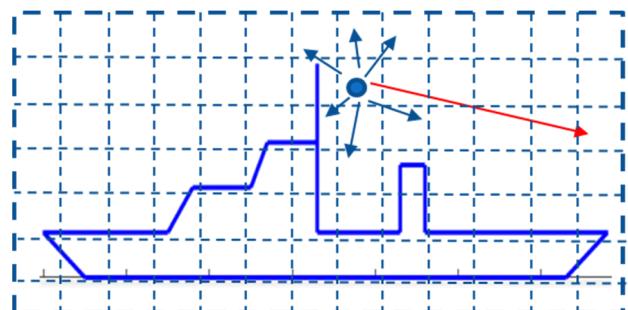


Fig. 1(a) Direct ray

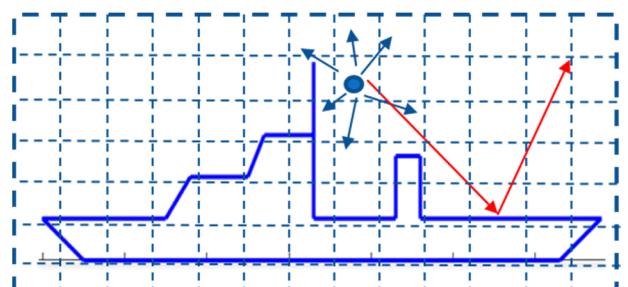


Fig. 1 (b) Reflected ray

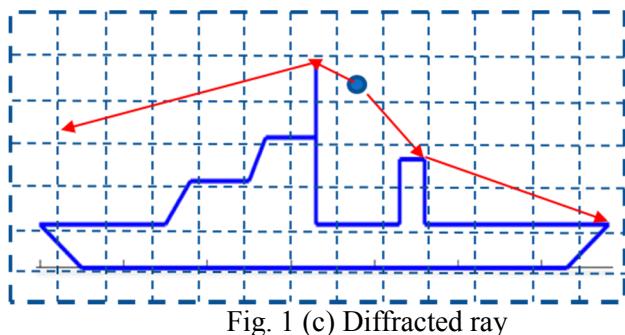


Fig. 1 (c) Diffracted ray

As it is seen in Fig. 1, there is an antenna on the right of the mast. Direct, reflected and diffracted rays emanates from antenna is demonstrated.

3 GO and UTD Models

Geometrical optic model can explain free space propagation, reflection and refraction phenomena. In geometrical optic model there is sharp shadow boundary line [9]. There is no lit region behind the obstacle as shown in Fig.2.

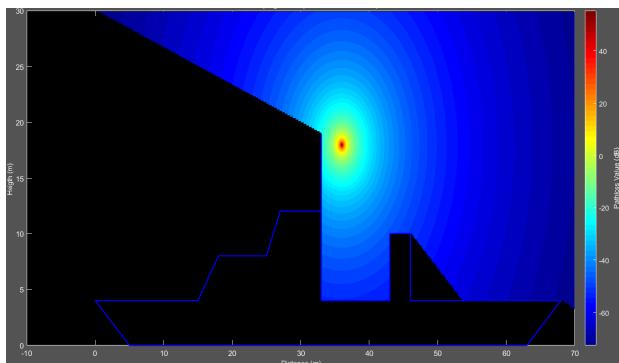


Fig.2. Illumination with Geometrical optic.

Electric field strength behind an obstacle in UTD model can be calculated by the formula [10] given by,

$$E = [E_i D] A(s) e^{-jks} \quad (1)$$

where, E_i and D are incident field and amplitude diffraction coefficient, k stands for wave number, $A(s)$ symbolize spreading factor and finally s is travelling distance of electromagnetic wave. The amplitude diffraction coefficient [11] is expressed by,

$$D(\alpha) = -\frac{e^{-j\pi/4}}{2\sqrt{2\pi k \cos(\alpha/2)}} F[x] \quad (2)$$

where, α is diffraction angle as illustrated in Fig. 3. $F[x]$ is transition function in [12] and changes between 0 and 1.

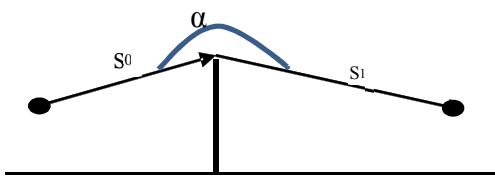


Fig.3. Diffraction Geometry

$A(s)$ is spreading factor and can be calculated by,

$$A(s) = \sqrt{\frac{s_0}{s_1(s_1+s_0)}} \quad (3)$$

where, s_0 and s_1 are the distance before and after the diffraction, respectively. Reflected field can be expressed by,

$$E = \left[\frac{E_i R_{s,h}}{s} \right] e^{-jks} \quad (4)$$

where, E_i is incident field, s is total distance and $R_{s,h}$ reflection coefficient for soft and hard polarizations. Direct field can be calculated by

$$E = \left[\frac{E_i}{s} \right] e^{-jks} \quad (5)$$

where, E_i is incident field and s is total distance.

Below the shadow boundary line there is diffracted field as it is depicted in Fig. 4.

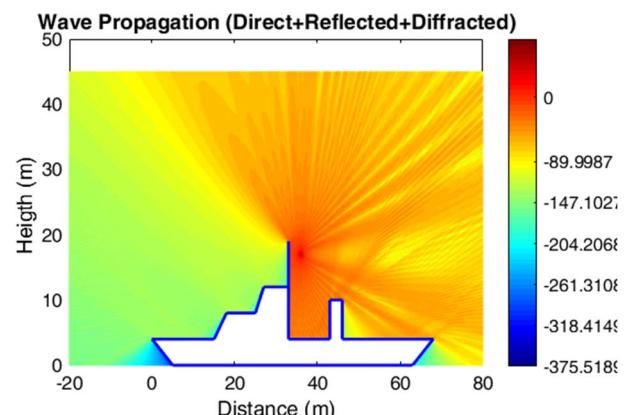


Fig.4. Coverage with UTD Model

4 Base Station Optimization

In order to determine optimum base station location all candidate positions are tried, coverage maps are extracted for this position and then the best one is selected. Coverage map is extracted by using of total direct and diffracted fields equations as previously mentioned.

As an example operating frequency is selected 1 GHz. A building matrix (17x17) is generated with height of buildings in z-direction. This matrix includes randomly distributed 289 building's heights between 0 and 50 as shown in Table I. 17

buildings are deployed uniformly x-direction between 0-800 with equal space. 17 buildings are deployed uniformly y-direction between 0-400 with equal space. As the third building in x and y direction is selected as a receiver, coverage map is demonstrated in Fig 5.

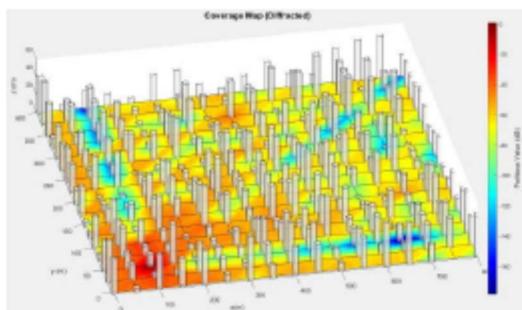


Fig. 5. Coverage map for transmitter position.

As it is illustrated in Fig. 5, electric field strength is 0 dB on the transmitted antennas. And field strength decreases as far away from transmitter. Moreover, if there is multiple diffraction, electric field decreases greatly (-160 dB).

In order to determine the optimum base station location, firstly transmitter antenna position is changed and coverage map extracted. Then total electric field for all transmitter position is found by adding the electric field in all receiving positions. Finally, one of the coverage maps is selected as an optimum map. Optimum base station location for the building matrix given in Table I, is depicted in Fig. 6.

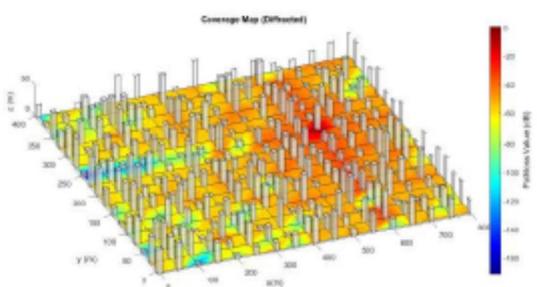


Fig. 6. Optimum coverage map with buildings

As it is shown in Fig. 6, optimum position to deploy the base station is the top of (13, 11) building. In other words, building is 600 m from x-direction and 250 m from y-direction. Base station location without buildings is shown in Fig. 7.

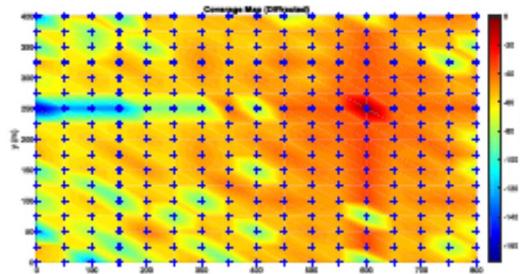


Fig. 7. Optimum coverage map without buildings

As shown in Fig. 7, the red place is the optimum base station location. The locations close to red place have relatively higher electric field (-20 dB) than far location (-160 dB).

5 Conclusion

Determination of optimum base station location is important to install more reliable broadcasting systems like radio, TV and GSM. It can be decided whether the threshold signal quality is provided or not. Coverage prediction is made with UTD and Geometrical optic models. UTD model removes the diffraction problem of Geometrical optic model. By optimization QoS can be increased and required base station number can be reduced. And so, healthier environment is provided.

Acknowledgement

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TABLE I Building Heights

40	45	6	45	31	4	13	27	47	48	7	48	47	24	40	7	21
45	39	47	32	1	42	46	33	37	37	19	32	8	35	1	13	2
4	41	34	15	47	1	21	19	38	39	9	24	22	32	35	37	13
33	32	8	5	24	47	17	29	11	37	12	25	34	44	47	27	6
7	12	42	12	40	12	46	17	9	12	30	23	17	41	29	27	45
14	37	37	19	28	3	2	26	38	46	6	28	23	0	16	8	39
15	26	8	30	13	32	34	37	22	4	11	45	7	41	26	49	3
22	5	48	0	38	40	43	4	19	12	40	21	45	9	13	7	6
43	28	27	7	42	31	17	25	20	3	11	6	9	11	20	2	45
47	24	24	16	45	18	5	39	19	12	20	4	6	47	47	28	2
11	17	41	0	2	8	32	36	32	22	27	14	37	9	34	9	18
31	39	4	46	38	24	21	22	15	25	25	40	39	32	18	40	26
17	46	43	27	31	29	10	15	23	11	42	9	11	8	11	21	15
46	21	9	45	48	21	5	12	20	29	13	30	35	11	5	14	15
21	25	4	13	40	1	46	36	24	28	11	22	48	27	26	11	24
31	33	19	18	49	1	44	45	39	4	13	16	33	6	36	5	32
24	38	35	45	44	16	34	9	1	37	25	23	45	30	30	42	40