# The Development of a Computer Aided Instruction in Antenna Design and Coverage Analysis of Wireless Communication Networks

[#]Yong Bae Park
Department of Electrical and Computer Engineering, Ajou University
San 5, Woncheon-dong, Suwon 443-749, Korea, yong@ajou.ac.kr

## Abstract

This paper describes the development of a computer aided instruction in antenna design and coverage analysis of wireless communication networks. A base station antenna is designed by an antenna simulation tool and the antenna parameters including radiation pattern and gain are used for the coverage analysis in a wireless network simulation tool.

**Keywords :** Antenna design Coverage analysis

## 1. Introduction

The engineering accreditation organization, the Accreditation Board for Engineering Education of Korea(ABEEK) emphasizes the capstone design to fulfil the ABEEK accreditation requirements. The capstone design offers students the opportunity to realize original and creative solutions to real engineering problems. The Department of Electrical and Computer Engineering, Ajou University has developed the examples of the capstone designs in various fields of electrical engineering including microwave and antenna engineering. In this paper, we'll introduce an example of the capstone design for antennas and propagation. A base station antenna for WiMAX band is designed by using an antenna simulation tool-IE3D. The antenna parameters including the antenna radiation pattern and gain is used for coverage analysis in a wireless network simulation tool-CellTREK/OPT. The coverage for WiMAX network in an urban area is predicted and improved by redesigning the base station antenna. This example of capstone design could help students to understand the antenna theory and its application in a real wireless communication network.

## 2. Antenna Design and Coverage Analysis

The base station antenna for WiMAX network is designed by using IE3D[1]. The antenna specification is given by Table 1[2].

Table 1: Antenna specifications

| Frequency[MHz] | Radiation pattern | HPBW | Directivity | Return loss |
|---|---|---|---|---|
| 2300~2327 | Omni-directional | $30^o$ | > 5dBi | < -10dB |

We design and simulate the 3-sector rectangular patch antenna as shown in Figure 1[3]. The designed antenna satisfies the specifications in Table 1 and its gain is 3.5 dBi. The parameters of designed antenna are given by Table 2.

Table 2: Parameters of designed antenna

| Substrate dielectric constant | Substrate thickness[mm] | Size[mm*mm] | Feeding point[mm] |
|---|---|---|---|
| 1 | 0.5 | 65.217*64.499 | 20 |

We upload the antenna data including radiation pattern into the wireless network simulation tool-CellTREK/OPT[4] and analyze the coverage of WiMAX network in a dense urban area. The

coverage requirements for WiMAX network are that the downlink RSSI is bigger than -75dBm and the down like SNR is larger than -3.5dB.

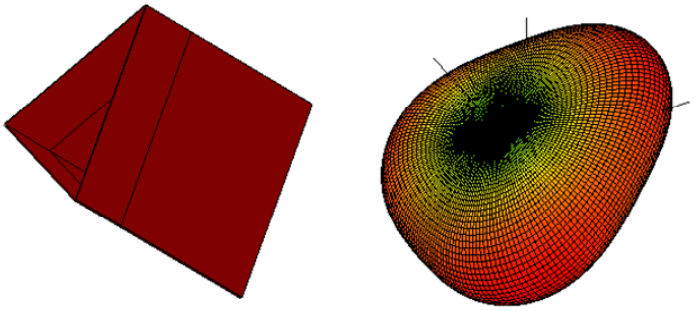
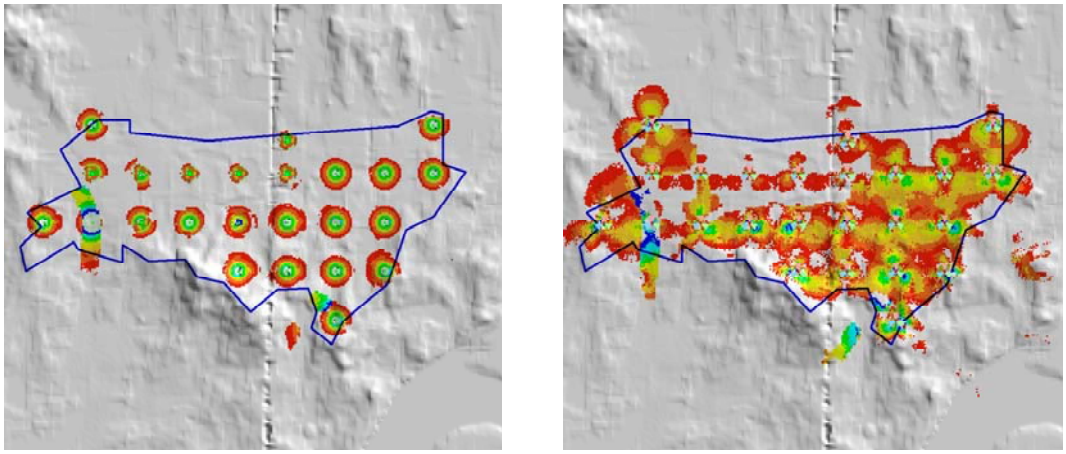


Figure 1: 3-sector rectangular patch antenna and its radiation pattern

The base station using the designed antenna covers 0.1 $km^2$ area and about 88 base stations are needed to cover the Jung-gu area in Seoul when the modified Hata propagation model is used. We design the 4-array patch antenna to enhance the antenna gain and its gain is about 16.2 dBi. The improved coverage is about 0.4 $km^2$ and the number of the base stations to cover the same area reduces to about 24. Figure 2 shows the result of the coverage analysis of the WiMAX network in the Jung-gu area Seoul before and after improving the antenna, respectively.



(a) Before improving antennas (b) After improving antennas

Figure 2: Result of coverage analysis (RSSI) for 24 base stations

The coverage area increases from 29% to 64% by using the improved antenna. We add more base station to cover the whole area of Jung-gu. Figure 3 and Table 3 illustrate the morphology distribution and the morphology correction factor in Jung-gu area, respectively.

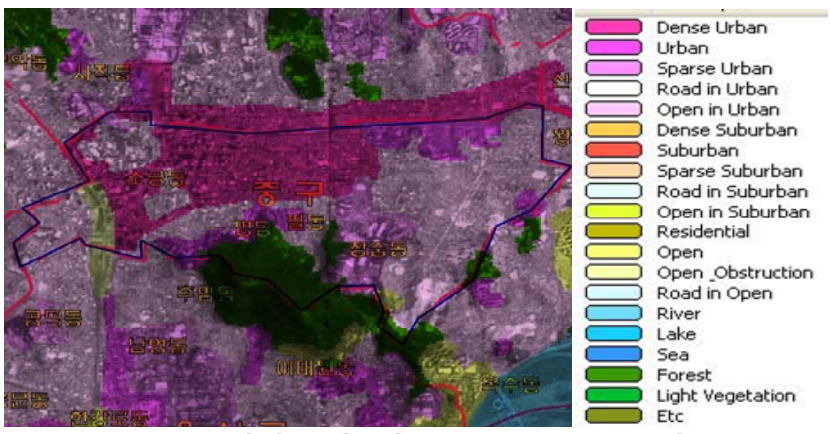



Figure 3: Morphology distribution in Jung-gu, Seoul

Table 3: Morphology correction factor in Jung-gu, Seoul

| Morphology | Dense urban | Urban | Sparse urban | Open in urban | Open | Open &Obstruction | Forest |
|---|---|---|---|---|---|---|---|
| Ratio [%] | 26.73 | 9.67 | 8 | 44.46 | 0.55 | 2.1 | 8.48 |
| Correction factor [dB] | 5 | 0 | -3 | -3 | -20 | -17 | -3 |

We add 8 base stations in dense urban areas and adjust the direction of antenna sectors. Figure 4 shows the simulation result for coverage analysis for 32 base stations. The coverage increases to 78% by adding base stations in dense urban areas.

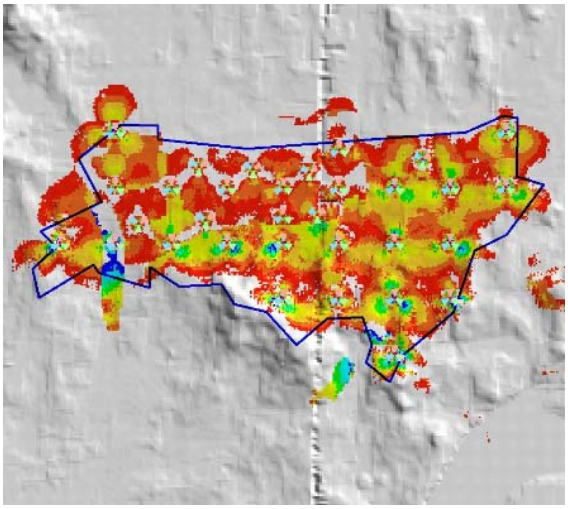


Figure 4: Result of coverage analysis (RSSI) for 32 base stations

## 3. Conclusion

We have developed a computer aided instruction in antenna design and coverage analysis of wireless communication networks for the capstone design. A base station antenna is designed by an antenna simulation tool and the antenna parameters including radiation pattern and gain are used for the coverage analysis in a wireless network simulation tool. Our example of the capstone design could help students to understand the antenna theory and its application in a real wireless communication network.

## References


[1] IE3D user manual, http://www.mentor.com/electromagnetic-simulation/.
[2] S. K. Lee and H. C. Bang, IMT-2000 CDMA Technology, Sehwa, 2001.
[3] C. A. Balanis, Antenna Theory, 3rd edition, Wiley, 2005.
[4] CellTREK/OPT user manual, http://www.celltrek.com.


.