Enhance Mobile Quality of Service using Topography and 3D Modeling

تحسين جودة البيانات النقالة باستخدام تقنيه ثلاثية الابعاد و الطبيعه الجغرافيه

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الآيـــــــة

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿ اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ * خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ * اقْرَأْ وَرَبُّكَ الْأَكْرَمُ * الَّذِي
عَلَّمَ بِالْقَلَمِ * عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ ﴾

صدق الله العظيم

سورةالعلق(الآيات 1–5)

Dedication

I dedicate this thesis

To my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

To all knowledge seekers and providers,

To all my teachers,

To all my colleagues,

And to my all friends and classmates.

Acknowledgement

I would first thank God for what we have reached and to complete this research. I would also like to thank my thesis supervisor Prof. Dieter Fritsch SUSTECH Visiting Professor, he was guidance me in the right direction.

I'd like to grasp this opportunity for most to express my greatest thanks to all who have helped me towards the successful completion of this research.

Last but not least, I have to confirm that my completion of this project could not have been accomplished without the support of my family, my friends, my colleagues at work and my classmates.

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Abstract

Mobile communication plays a major role in today's world. So telecommunication companies have to provide good services for their customers and, as we face now, having difficulties to build new of antennas due to high costs.

Geographic Information System Technologies help us to solve problems that connect with telecommunications and quality of service problems using GIS's and Cellular Expert.

In this research we want to improve the antenna coverage in a way, that we have as much as possible integrated impact factors like topography, buildings or other obstacles like trees or other things that disrupt the signals. For this reason we are using 3D modeling techniques applying Esri's ArcGIS tools, and the Cellular Expert software to simulate antennas positions and to calculate the intersections of the signal transmission with 3D buildings. Before accomplishing this task we have to build a 3D map using ArcScene for Level of Detail 1 (LoD1) models for buildings.

Chapter 1

Introduction

Chapter 1

Introduction

1.1 Introduction

Nowadays, mobile communication plays a major role in today's world. Thus, wireless communication systems are very popular due to its wide advantages. From a customer's point of view, we can say, that most of the customer requirements related to communication from one place to another place are mostly fulfilled. The initialization of these wireless communication systems started to satisfy the minimum requirements of the customers, therefore the first generation (1G) mobiles were introduced end of the 1990s. Thereafter very soon, to improve the customer satisfaction considerably, the requirements were increased and therefore an evolution started from 1G to 4G today.

In order to guarantee always a maximum Quality of Service (QoS) this measure is given maximum priority, not only in Sudan, but all around the world. Voice traffic is very delay sensitive – in the contrary data traffic is loss sensitive. QoS schemes, which try to incorporate both voice and data traffic, are therefore highly desired. In more detail, QoS is the ability to provide different priorities to different applications, customers, or data flows, or to guarantee a certain level of performance to a data flow.

In design of any system Quality of Service (QoS) is one of the important issues from both, customers and providers point of view. That means customers expect the service of best quality from the system providers, and providers want to give best quality of service to the customers. In case of wireless communication systems the providers want to give this best service to their customers as well, therefore there is aneed to cover wide areas through distributing the towers around the whole country. In this research, a new approach is proposed to enhance the 3D coverage.

1.2 Research Problem

To build a new tower is very expensive; we need to improve network coverage and optimize the network performance based on the highest location (topography of the earth) to make sure that it coversa big area. This can be accomplished by using GIS and 3D Modeling.

1.3 Aims and Objectives

1.3.1 Aims

Overall speaking, we want to design a model that will choose the best sites to redirect the antennas of telecommunication towers. By this action better services to the telecommunication companies can be provided, and on the other hand, it offers best facilities for a high QoS for customers.

1.3.2 Objectives

Experimental studies for Quality of Service (QoS) simulations in Mobile Networks using GIS Data and the Cellular Expert tool.

1.4 Methodology

- A model has to be developed to calculate the signal transmission and intersections of transmitted signals with buildings to detect shadow areas, using GIS technologies. A commonly used software package is the Esri ArcGIS, which can provide 2.5D modeling using topography.
- To extend 2,5D to 3D we must model the buildings in 3D, and will study methods for Sudan to provide 3D city models from satellite remote sensing data and airbornephotogrammetry.

1.5 Requirements

- Height data from Sudan in form of raster Digital Terrain Models and Open Street Map data. All data offered on Internet are searched for and will be used if appropriate. So far only 2.5D can be used with the available height data. For real 3D investigations it is necessary to provide full coverage 3D city models using satellite remote sensing and/or aerial photogrammetry. A first approach will use Level of Detail 1 (LoD1) models wrapping every building into a box.
- Existing Base Transceiver Stations (transmitters and receivers) with their coordinates as geo-reference.
- A powerful GIS software package.

Chapter 2

Literature Review

Chapter 2

Literature Review

2.1 Previous Studies

2.1.1 3D Analysis and Visualization

Besides comprehensive capabilities of the software packages 3D Analyst and Cellular Expert, additional software provides additional 3D analysis functionality. It includes:

- Generation and visualization of 3D antenna pattern using Free Space, Hata or SUI algorithms for optimization of antenna orientation, especially in city areas with tall buildings to assess the coverage of upper floors of the buildings.

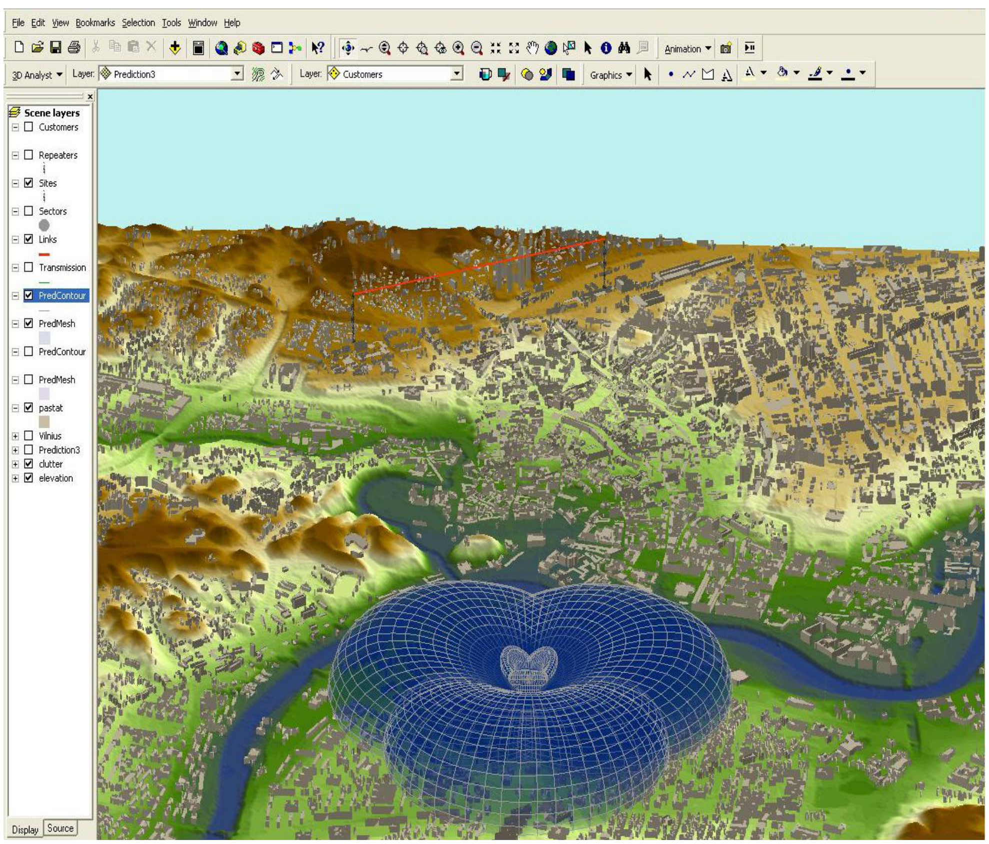


Figure (2-1):3D antenna pattern visualization

- Generation of 3D Fresnel for 3D profile analysis.

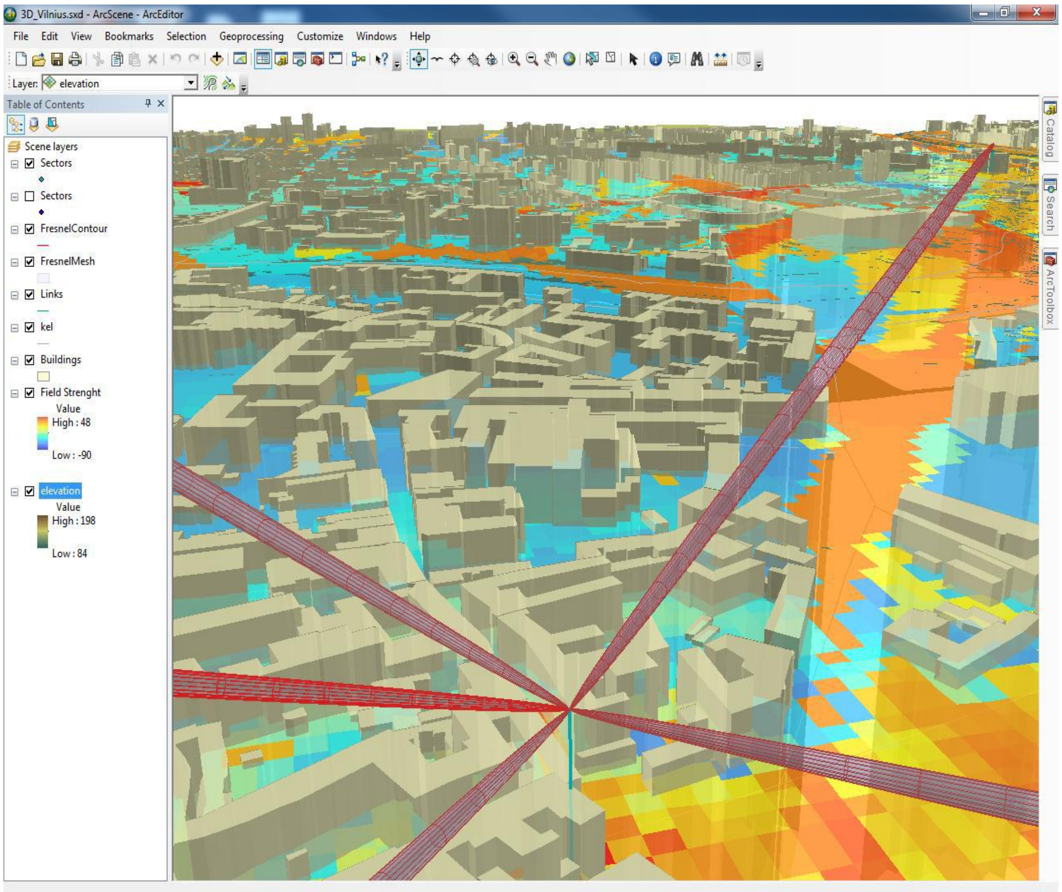


Figure (2-2):3D Fresnel visualization

Cellular Expert allows for overlaying 3D antenna pattern and prediction result, such as field strength, best server or interference prediction on 3D terrain. This feature is very useful for planning in dense urban areas with high resolution data.

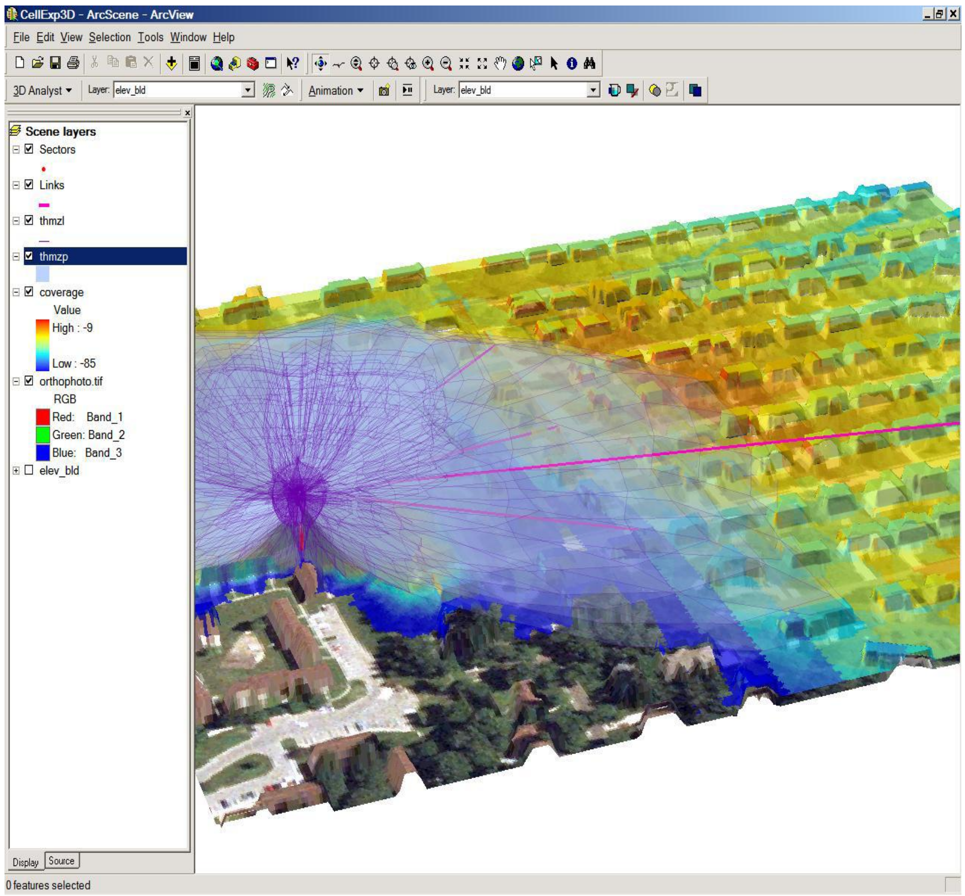


Figure (2-3):3D antenna pattern and field strength coverage map for WiMAX network

2.1.2 Topography

Topography is, in a broad sense, the description of the surface' shapes and features of the Earth. It is concerned with the local details in general, including natural and artificial features. It involves recording terrain, the3D quality of the surface, and the identification of specific landforms. A safe site is ensured by adhering to safety codes and placing buildings with respect to topography.

The following topographical features were identified as spatial safety aspects:

1. Slope

This feature is described by the ratio of rise/fall divided by the run between two points. It indicates the steepness, incline, or grade. Ecological damage and slope in stability in adjacent areas are caused by the cutting of a hill slope (NBC, 2005). Therefore, cuttings shall not be undertaken unless appropriate measures are taken to avoid such damages to ensure site safety. In India, Model Town and Country Planning Legislation Zoning Regulations Development (2007) controls building regulation by-laws for hazard zones. NBC (2005) suggests, that no construction should be ordinarily undertaken in areas with slopes above 301 or in areas that fall in land slide hazard zones.

2. Elevation

The elevation of a location is its height above a fixed reference point, most commonly the Earth's mean sea level. It is one of the important factors associated with site safety. For example, a location at a high-elevation is considered suitable for over head tanks; where as a location at a low elevation is suitable for rain-harvesting water tanks.

2.2 Related Works

(K.Ali, H. D. Mohammed, J. S. Abdaljaba, 2015[2]): In this paper, the authors worked on the redistribution of the towers based on a fixed value for the BTS powers, towers, height, cell radius, and geographic location of the towers. For the new distribution they found a reduction for the number of mobile towers from 22 to 19 towers. Above all, they could reduce the interference area, eliminate weak areas, increase active coverage areas, and reducing the distances between the server and the BTS towers. The process of distribution, such as the optimization in the number of towers had several objectives, such as reducing the costs for the Communication Company; reducingthe environmental pollution and electromagnetic radiation, improving urban aesthetic of the city, minimizing the interference region between the towers, and improving communication system tools by reducing the distances between the towers and the server.

The process of studying the distribution of mobile communication towers with the help of GIS was the target of this paper, where the real locations of the towers belonging to the communication company were added to the GIS software in order to deal with it. Patterns for all towers were drawn according to the cell radius. Thus, the cell radius was selected from the existing distances between the towers, whereas the radius does not have any effect on the capacity of the communication system. They noticed that during the process of analysis, there were areas like over-lapping area, weak area, and active area at the cell radius equal to R=200m and R=300m. Also, from the analysis it was found: There are more than interference regions which negatively affect the work of the system by generating multipath fading and losses in BTS power. The weak area at these distances amounted to a total of 1.442km2 for R=200m. In addition, the weak area equals to 1.044km2 at R=300m. The active coverage area did not meet the ambition which amounted to 2.358 km2 for R=200m, and amounted to 1.798Km2 for R=300m.

Finally, a re-distribution of the towers has been proposed, and as an important result, the number ofthe towerscould be decreased. Furthermore, the weak area and the interference region had been reduced as well, in order to ensure maximum access of the active coverage area.

(T. H. Kolbe[8]): This paper gives an overview about CityGML, its modeling aspects and design decisions. Moreover, recent applications, and its relation to other 3D standards like IFC, X3D, and KML are presented.CityGML is both a semantic model (specified by a formal data model) and an exchange format for virtual 3D city and landscape models. Rules for the acquisition and structuring of urban objects follow implicitly from this semantic modeling approach. Based on long discussions with many professionals during the development of CityGML, this format is (of course) not a guarantee, but a reasonable basis for the definition of data structures.

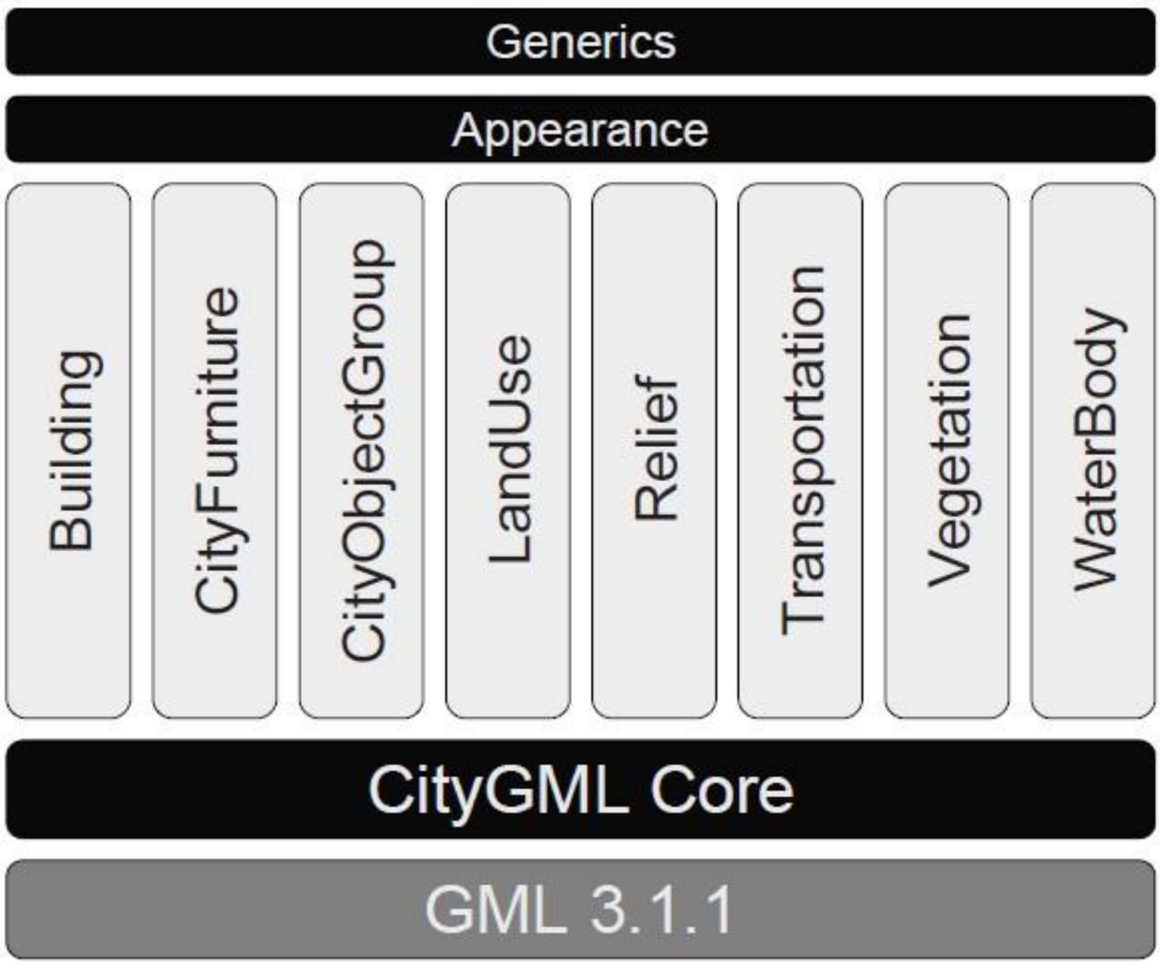


Figure (2-4): Modularization of CityGML 1.0.0. Vertical modules contain the semantic modeling for different thematic areas.

It is now a topic of future work to bring CityGML to a wider adoption and discuss and learn from the experiences of a much broader user base. The data model of CityGML balances between strictness and genericity.

For this purpose it consists of three main parts: 1) the core thematic model with well-defined LODs, classes, spatial and thematic attributes, and relations; 2) GenericCityObjects and generic attributes allow the extension of CityGML data ‘on-the-fly’; and 3) ADEs facilitate the systematic extension for specific application domains.

CityGML also balances between simple objects and objects with complex thematic and spatial structures. Data is given high flexibility to grow with respect to their spatial and semantic structuring as well as their topological correctness in different stages of data acquisition or along a city model processing chain.

Finally,CityGML is complementary to visualization standards like X3D or KML. While these address presentation, behavior, and interaction of 3D models, CityGML is focused on the exchange of the underlying urban information behind the 3D objects.

(V. Barrile, G. Armocida, G.Bilotta, 2009[9]):A geographic information system was realized in various steps and has demanded much time, to get the data employed and for the implementation of the instrumental survey necessary for getting coordinates of some sites and the electric field values. The first phase has been dedicated to the collection of the necessary data in order to know the exact positioning of the systems installed on the municipal territory of Reggio Calabria. For being able to realize the calculation in the study area (sited in Piazza dellaLibertà) also the radio electric characteristics of the installed systems had to be known. The relative data for registering the systems have been supplied from three of the four main providers of mobile telephony, while it has been possible to have all the characteristics of the systems sited in buildings adjacent to the Piazza dellaLibertà.

The chosen area is characterized by a peculiar urban place and from an important presence of BTS installed on the buildings. Every point of measure has been found cartographically, with the aid of an orthophoto and GPS. Moreover, through the layer of the buildings, it has been found the height from the ground to the sensor position.

From adata analysis, the model appraisal overstates in some cases the value effectively measured with the probe to wide band, while in others it is almost coinciding. In two cases it understates the value found with the appropriate instrumentation.

Generally the considered model stretches to overstate the field values systematically against those to be measured. In this case, the values tend to coincide in the comparison points since probably several measures have been realized on the terrace of the buildings, where there is no presence of obstacles and the model of free space is sufficiently valid.

Moreover,for oneanalyzed site the providers put active all the carriers for being this a central zone of the city. Naturally for the points where the measured value is higher than that estimated, it is necessary to specify that the instrumental measurements can be influenced by the presence of the electric field generated from sources like radio-TV, and from other emitters for public services, like the antennas of the civil protection, the Fire Departments, of the white cross, military services, and various police services.

(Munene, E.N., Kiema, J.B.K., 2014[4]): This research has demonstrated that powerful spatial analysis tools are available in Geographic Information Systems (GIS), to be used to tackle this problem in a much more efficient and simpler way. Particularly for dense urban environments, where the BTSs must be located on building rooftops.

Wireless network planning is a complicated task for network engineers. The most important consideration, particularly at the beginning of the wireless network design process, is optimizing the radio signals' spatial coverage of the target area. Dense urban environments characterized by high-rise buildings are particularly challenging to the network engineer owing to the numerous factors, which affect the signals and which must be modeled as accurately as possible.

As demonstrated in this study, the 3D ray-tracing model, when used with 3D geodatabases of the target area, is the most accurate method of modeling signal coverage. The location of BTSs plays a crucial role in ensuring optimal signal coverage. Thus in wireless network design, the determination of the best BTS sites that offer optimal signal coverage is a very important consideration, which must be handled with utmost seriousness.

This is particularly important due to the fact that setting up of a single BTS requires colossal amounts of money and thus elimination of any redundant BTS(s) would result in significant savings for the network operator. The problem of optimum BTSs locations is a target of much research work with various algorithms being employed. However, most of these algorithms are very complex and computationally intensive.

(A. H. AL-Hamami, S. H. Hashem, 2011[6]): Distributing and placing towers is a difficult problem to be modeled. So the presented work is used as an approximation for an optimal solution. Using GIS and DEM especially DTM making the division of the area more accurate and presenting the surfaces of the square in a more precise way. Building spatial databases as flat databases will make the spatial mining much more efficient, than that mining using one level only. Thus, this will reduce time and space consumption, compared with results extending the mining to multilevel. The authors proposed a novel approach for building a spatial database to accommodate all the necessary requirements for applying association rules, and then extract all the patterns, which help in distributing the towers. With the proposed spatial database the extraction of the association rules could be done by the traditional apriori algorithm without any confusing. That makes the proposed approach easy to use and understandable by the administrators. Also the analysis step followed by extraction rules is easy because it depends on generalization and normalization determined by the miner. In this research, the classifier will be built without the need to measure the entropy of each attribute only -it depends on the position of the squares.

Chapter 3

Methodology

Chapter 3

Methodology

3.1 Study Area

3.1.1 Overview

KHARTOUM is the capital and second largest city of Sudan and Khartoum state. It is located at the confluence of the White Nile, flowing north from Lake Victoria, and the Blue Nile, flowing west from Ethiopia. The location, where the two Niles meet is known as “al-Mogran", meaning the confluence. The main Nile continues to flow north towards Egypt and the Mediterranean Sea.

Divided by the Niles, Khartoum is a tripartite metropolis with an estimated overall population of over five million people, consisting of Khartoum proper, and linked by bridges to Khartoum North (الخرطوم بحري al-Khartoum Bahri) and Omdurman(أم درمان Umm Durman) to the west.

Figure (3-1): Khartoum Location

3.1.2Location

Khartoum North or Bahri (Arabic: الخرطوم_بحري, al-KharṭūmBaḥrī) is the third-largest city in the Republic of Sudan. It is located on the east bank of the Blue Nile near its confluence with the White Nile, and bridges connect it with Khartoum to its south and Omdurman to its west.Coordinates: 15° 38' N, 32° 31' O.

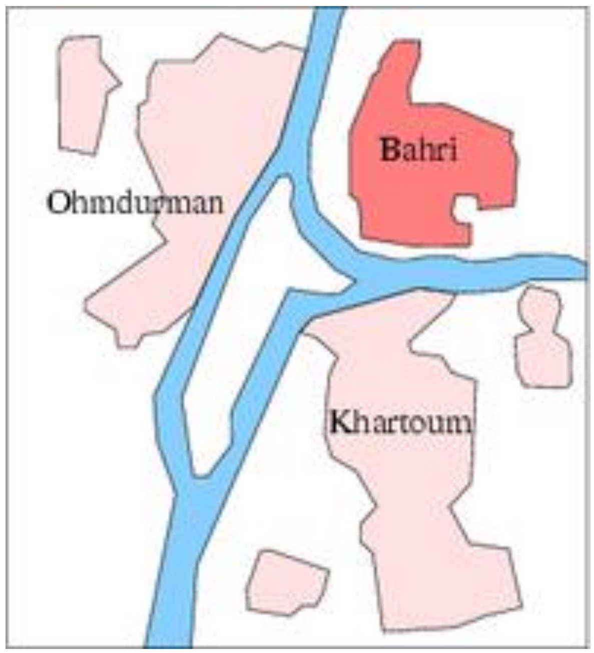


Figure (3-2): Study Area

3.1.3 Topography

Khartoum is located at an altitude of 380 meters (1,247feet) above sea level, above the plain flat ground surface with a slight slope towards the River Nile punctuated by hills and rocky protrusions and sand dunes scattered - it is giving the image of a flat terrain with minor ripples. Longitude: 15,6400°Latitude: 32,5200°.

3.2 Software

3.2.1 ArcGIS 10.3

ArcGIS is a Geographic Information System (GIS) for working with maps and geographic information. It is used for creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database.

The ArcGIS 9.3 includes a Geoprocessing environment that allowsfor execution of traditional GIS processing tools (such as clipping, overlay, and spatial analysis) interactively or from any scripting language that supports COM standards.

The ESRI version is called Model Builder and it allows users to graphically link Geoprocessing tools into new tools called models (similar to ERDAS IMAGINE software). These models can be executed directly or exported to scripting languages, which can then be executed in batch mode (launched from a command line), or they can undergo further editing to add branching or looping.

3.2.2 ArcScene 10.3

ArcScene is a 3D viewer that is well suited to generating perspective scenes that allow for navigating and interacting with 3D feature and raster data. Based on OpenGL, ArcScene supports complex 3D line symbology and texture mapping as well as surface creation and display of TINs. All data is loaded into memory, which allows for relatively fast navigation, pan, and zoom functionality. Vector features are rendered as vectors, and raster data is either down sampled or configured into a fixed number of rows/columns you set. ArcScene projects all data in an ArcScene document according to the first layer added to the document. Usually a planar projection, ArcScene is geared for those with smaller spatial datasets who want to examine a defined study area. ArcScene is better optimized for analysis. The 3D Analyst toolbar is fully supported in ArcScene, as are triangulated irregular network (TIN) surfaces. ArcScene renders subsurface data and volumes very well.

3.2.3 Cellular Expert

Cellular Expert TM is a wireless telecommunication network planning, optimization and data management solution, available to the telecommunication industry since 1995. Used in 37 countries by over 100 customers, the software is distinctive for its versatile functionality, calculation precision, multi-technology, intuitive usage and powerful GIS platform. Cellular Expert allows users to plan, optimize network and analyze information efficiently, to lower costs, increase profitability, and improve the quality of customer support services. The software is being constantly updated to support the latest technologies and includes the functionality based on real customer requirements giving a significant advantage for the user. Cellular Expert has several types of advanced coverage prediction algorithms for the modeling of microwave point-to-point, point-to-multipoint, fixed and mobile radio systems based on ITU-R, ETSI, COST 231 and IEEE standards and recommendations. The models can be calibrated using test drive data, and customized for certain types of terrain and land-use. The propagation models cover a distance range from several meters up to 150 kilometers and frequencies from 100 MHz up to 40 GHz. Cellular Expert supports Line of Sight, Hata, COST 231, Walfish-Ikegami, SUI type models and the ability to implement additional prediction models. Cellular Expert has the unique ability to use combined prediction models according to environmental conditions. Coverage prediction functionality includes Field Strength and Best Server calculations. There is a possibility to calculate N Best Servers and the number of servers per area.

Cellular Expert is more than just a network planning tool. The software is developed on the world’s leading Geographical

Information System (GIS) platform - ArcGIS™, which has been developed by the industry leader ESRI Inc. ArcGIS allows analyzing data and author geographic knowledge to examine relationships, test predictions, and ultimately make better decisions. ArcGIS provides a complete set of tools for modeling geographic information to support smarter, faster decisions.

ArcGIS can be used to discover and characterize geographic patterns, model and analyze against all sources of geographic data, optimize network and resource allocation, automate workflows through a visual modeling environment and use comprehensive spatial modeling and analysis tools to reveal answers in your data. Extensions for ArcGIS are specialized tools that add more capabilities and allow performing extended tasks such as spatial analysis, raster geoprocessing, three-dimensional analysis, map publishing and other tasks.

3.2.4 Google Earth

Google Earth is a virtual globe, map and geographical information program that was originally called Earth Viewer 3D created by Keyhole, Inc, a Central Intelligence Agency (CIA) funded company acquired by Google in 2004 (see In-Q-Tel). It maps the Earth by the superimposition of images obtained from satellite imagery, aerial photography and geographic information system (GIS) onto a 3D globe.

Google Earth displays satellite images of varying resolution of the Earth's surface, allowing users to see things like cities and houses looking perpendicularly down or at an oblique angle.

Google Earth can provide a lot of information about a location, and if you were to view it all at once, it would just be confusing.

3.3 Data

3.3.1 DTM

A Digital Terrain Model represents the Earth’s ground level above sea level. Each raster pixel has a value of altitude.

The sample DTM raster is presented below. One pixel is 50 meters square and has one height value. In reality, height is not the same in such one pixel area, so pixel’s value is height value in its center or maximum. The smaller the pixels, the more accurate is the grid, but needs more data for calculations.

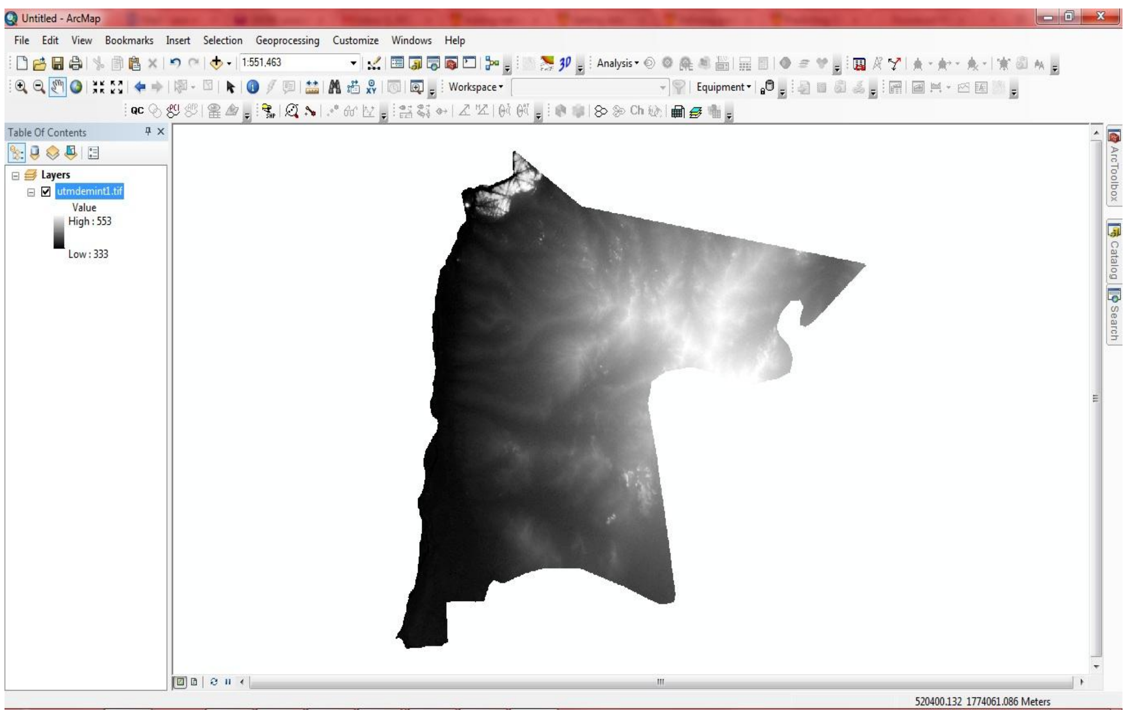


Figure (3-3): DTM Map

3.3.2 Obstacle height grid

The obstacles grid represents objects on the ground, which have width, length and height (for example buildings, dense forests, etc.). Some part of radio signals circumvent them, some reflect, etc.

The sample obstacles raster is presented below. One pixel is 5 meters square and has one height value. At edges of real obstacles, one pixel can represent just part of an obstacle. In such case, the obstacles height is assigned to all pixels (obstacle becomes bigger in raster than in reality). The smaller the pixels, the more accurate is the grid (sharper shapes of obstacles), but again needs more data for calculations.

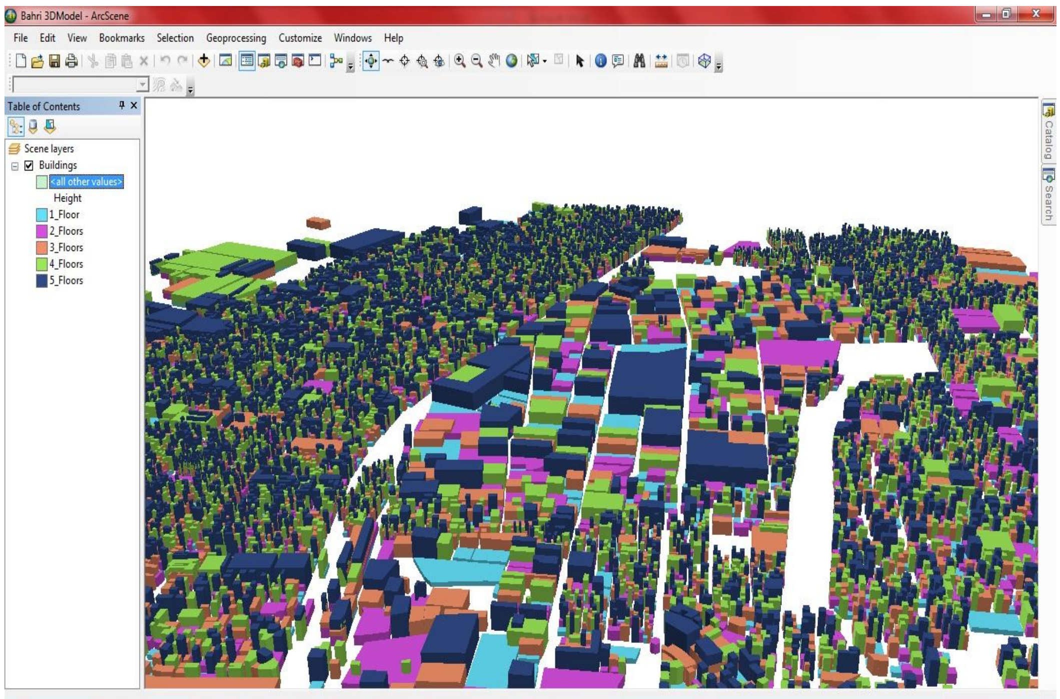


Figure (3-4): Obstacle Grid

Note: TheCellular Expert software automatically deploys the obstacles grid on top of the ground level grid representing the surface.

3.3.3 BTS

Existing Base Transceiver Stations (transmitters and receivers) with their coordinates as geo-reference.

3.4 Methodology

A. In this research 2.5D has been extended to 3D by modelling the buildings in 3D. Furthermore, new methods have been studied for

Sudan to provide 3D city models from satellite remote sensing data and airborne photogrammetry.

B. A model has been derived to calculate the signal transmission and intersections of transmitted signals with buildings to detect shadow areas, using GIS technologies.

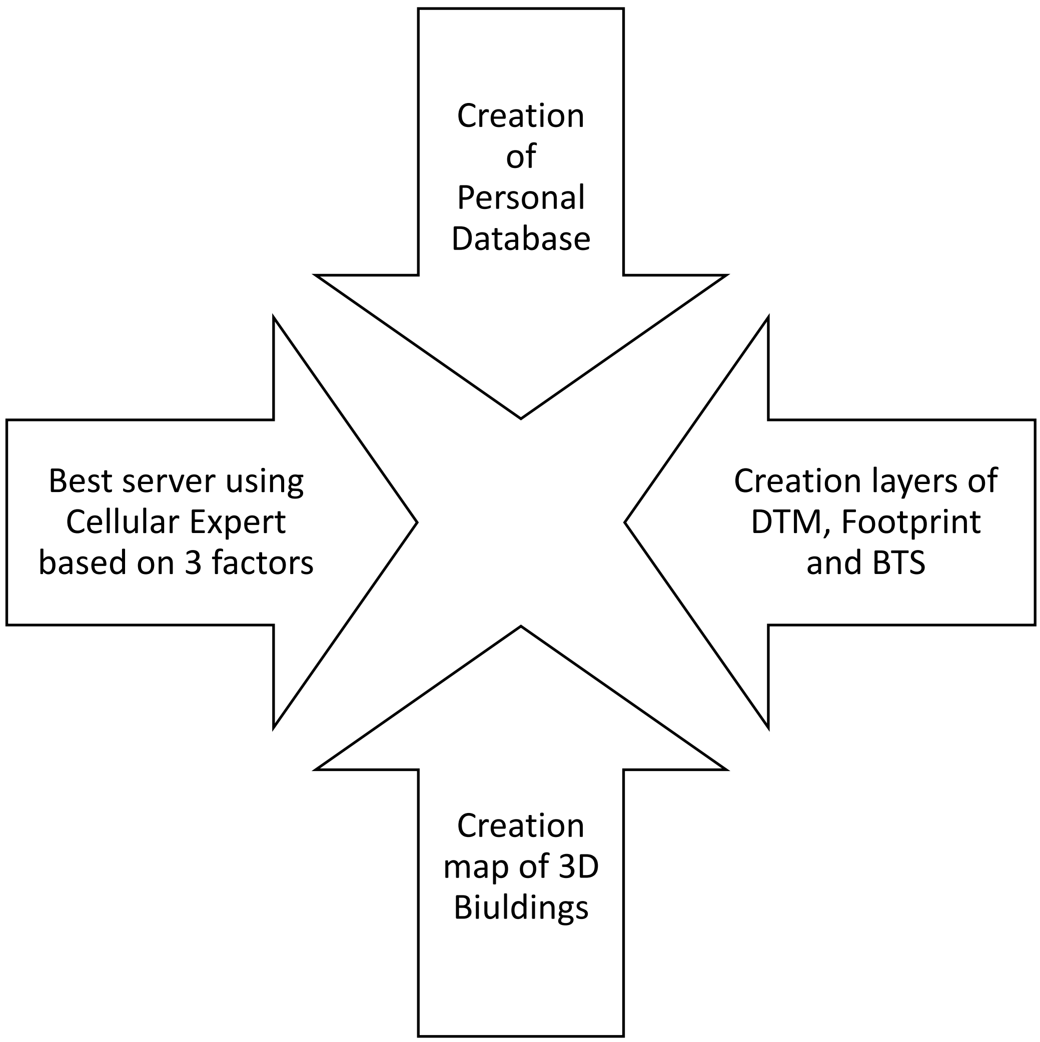


Figure (3-5): Methodology Schematics

Chapter 4

Simulation and Analysis

Chapter 4

Simulation and Analysis

4.1 Main Geographic Data

4.1.1 DTM

A Digital Terrain Model (DTM) pepresentsthe Earth's ground level above sea level; it is processed by Esri's ArcGIS in raster format, all height values are given in meters. The coordinate system is Cartesian x,y with a resolution (cell size) of 5meters or less (recommended for higher precision results) (see figure 4-1).

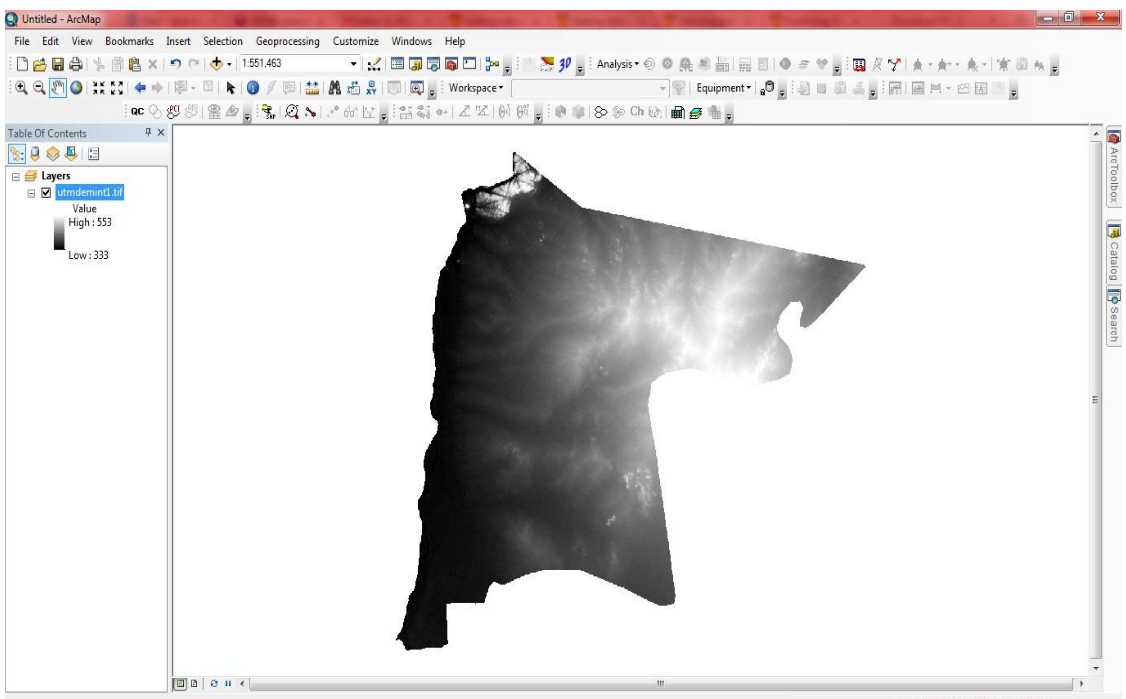


Figure (4-1): DTM Map of Study Area

4.1.2 Obstacle (buildings) height

The obstacles database represents objects on the ground, which have width, length and height.It can be entered in Esri'sArcGIS in raster format or as polygon objects, containing height attributes with height values also in meters. As before for the DTM the coordinate system is Cartesian x,y with resolution (cell size) of 5meters or less. For a better precision it is recommended to provide vector data polygons. Note: The Cellular Expert automatically deploys obstacles information as grid on top of the ground level grid making a Digital Surface Model (DSM) (see figure 4-3).

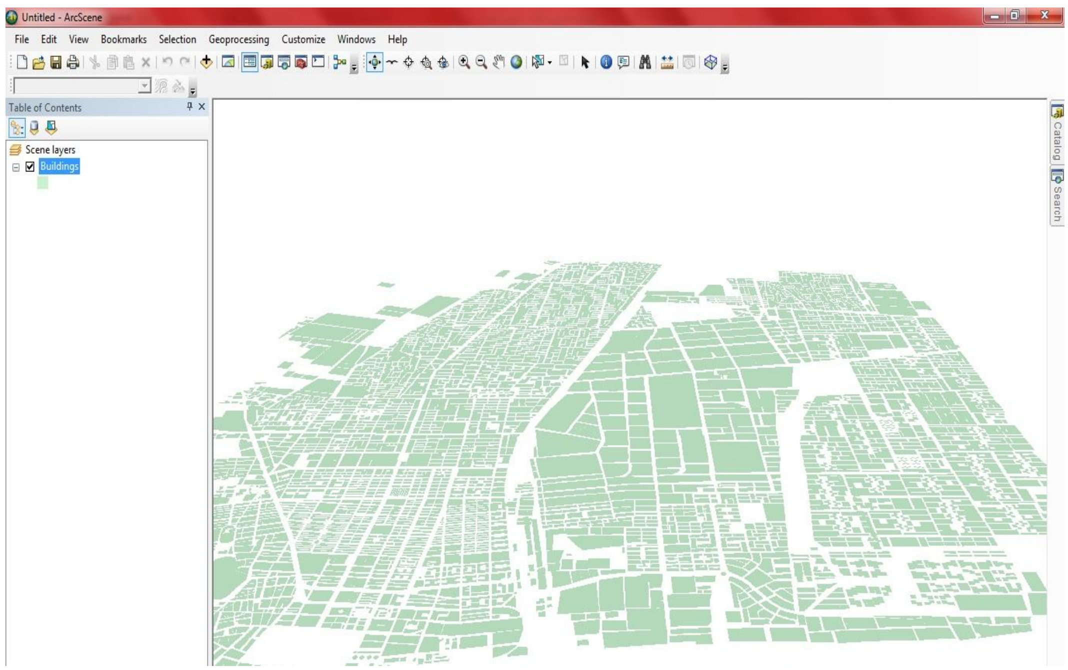


Figure (4-2): 2D Map of Study Area extracted from Google Earth, for each buildings including residential areas, industrial zones and so on.

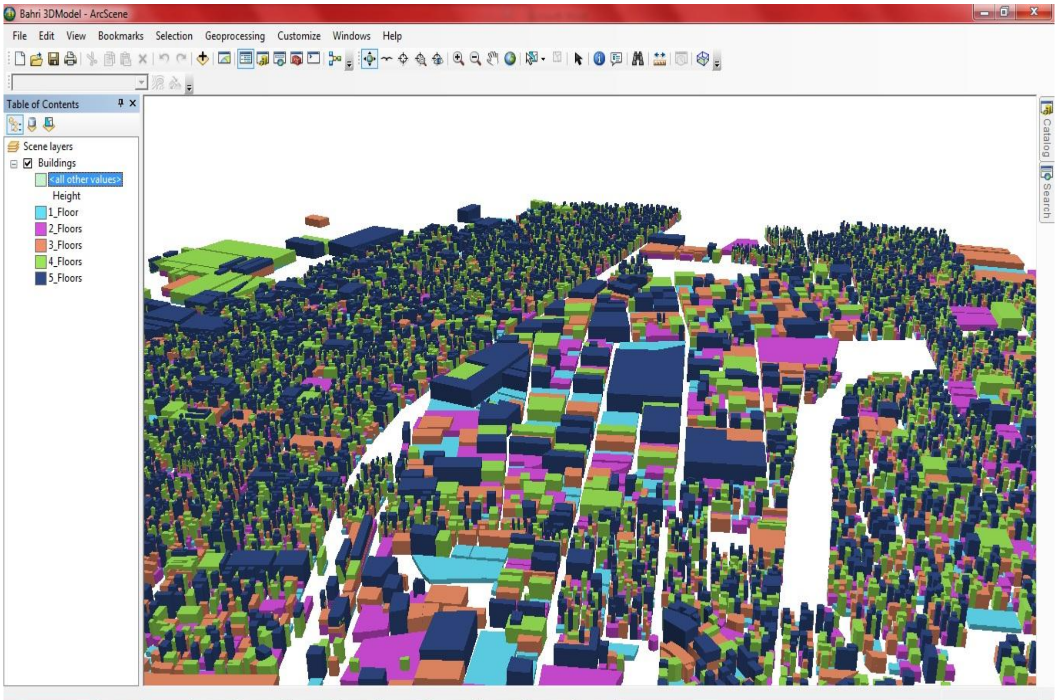
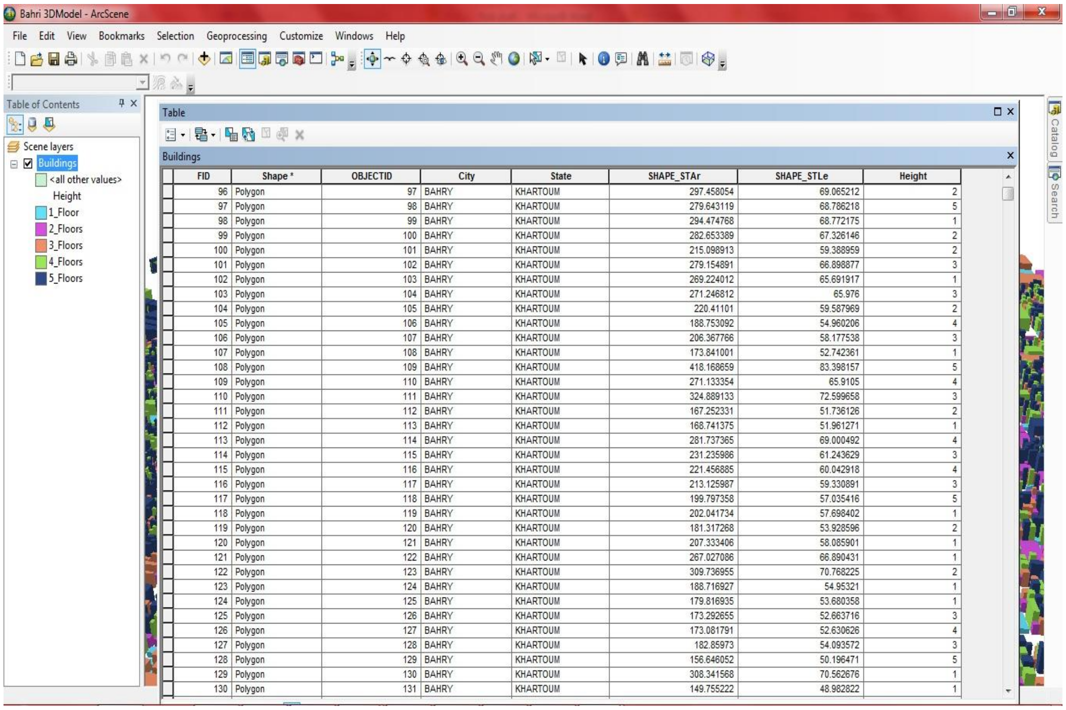


Figure (4-3): Map Extruded from 2D to 3D, classified by 5 colors each color represent the number of the floors.



FID	Shape *	OBJECTID	City	State	SHAPE_STAr	SHAPE_STLe	Height
96	Polygon	97	BAHRY	KHARTOUM	297.458054	69.065212	2
97	Polygon	98	BAHRY	KHARTOUM	279.643119	68.786218	5
98	Polygon	99	BAHRY	KHARTOUM	294.474768	68.772175	1
99	Polygon	100	BAHRY	KHARTOUM	282.653389	67.326146	2
100	Polygon	101	BAHRY	KHARTOUM	215.098913	59.388959	2
101	Polygon	102	BAHRY	KHARTOUM	279.154891	66.898877	3
102	Polygon	103	BAHRY	KHARTOUM	269.224012	65.691917	1
103	Polygon	104	BAHRY	KHARTOUM	271.246812	65.976	3
104	Polygon	105	BAHRY	KHARTOUM	220.41101	59.587969	2
105	Polygon	106	BAHRY	KHARTOUM	188.753092	54.960206	4
106	Polygon	107	BAHRY	KHARTOUM	206.367766	58.177538	3
107	Polygon	108	BAHRY	KHARTOUM	173.841001	52.742361	1
108	Polygon	109	BAHRY	KHARTOUM	418.168659	83.398157	5
109	Polygon	110	BAHRY	KHARTOUM	271.133354	65.9105	4
110	Polygon	111	BAHRY	KHARTOUM	324.889133	72.599658	3
111	Polygon	112	BAHRY	KHARTOUM	167.252331	51.736126	2
112	Polygon	113	BAHRY	KHARTOUM	168.741375	51.961271	1
113	Polygon	114	BAHRY	KHARTOUM	281.737365	69.000492	4
114	Polygon	115	BAHRY	KHARTOUM	231.235986	61.243629	3
115	Polygon	116	BAHRY	KHARTOUM	221.456885	60.042918	4
116	Polygon	117	BAHRY	KHARTOUM	213.125987	59.330891	3
117	Polygon	118	BAHRY	KHARTOUM	199.797358	57.035416	5
118	Polygon	119	BAHRY	KHARTOUM	202.041734	57.698402	1
119	Polygon	120	BAHRY	KHARTOUM	181.317268	53.928596	2
120	Polygon	121	BAHRY	KHARTOUM	207.333406	58.085901	1
121	Polygon	122	BAHRY	KHARTOUM	267.027086	66.890431	1
122	Polygon	123	BAHRY	KHARTOUM	309.736955	70.768225	2
123	Polygon	124	BAHRY	KHARTOUM	188.716927	54.95321	1
124	Polygon	125	BAHRY	KHARTOUM	179.816935	53.680358	1
125	Polygon	126	BAHRY	KHARTOUM	173.292655	52.663716	3
126	Polygon	127	BAHRY	KHARTOUM	173.081791	52.630626	4
127	Polygon	128	BAHRY	KHARTOUM	182.85973	54.093572	3
128	Polygon	129	BAHRY	KHARTOUM	156.646052	50.196471	5
129	Polygon	130	BAHRY	KHARTOUM	308.341568	70.562676	1
130	Polygon	131	BAHRY	KHARTOUM	149.755222	48.982822	1

Figure (4-4): Full information of each building within the study area, containing the block name, block number, city, state and height.

4.2 Base Station Related Data (For Sectors and Sites)

4.2.1 Antennas

Information about antennas is given in MSI Planet Antenna File Format or tabular data containing gain and attenuation from 1 to 360 degrees in horizontal and vertical planes. Attached to this data are the coordinates (with coordinate system), height above ground level in meters, direction angle (azimuth) in degrees clockwise, Tilt angle in degrees.

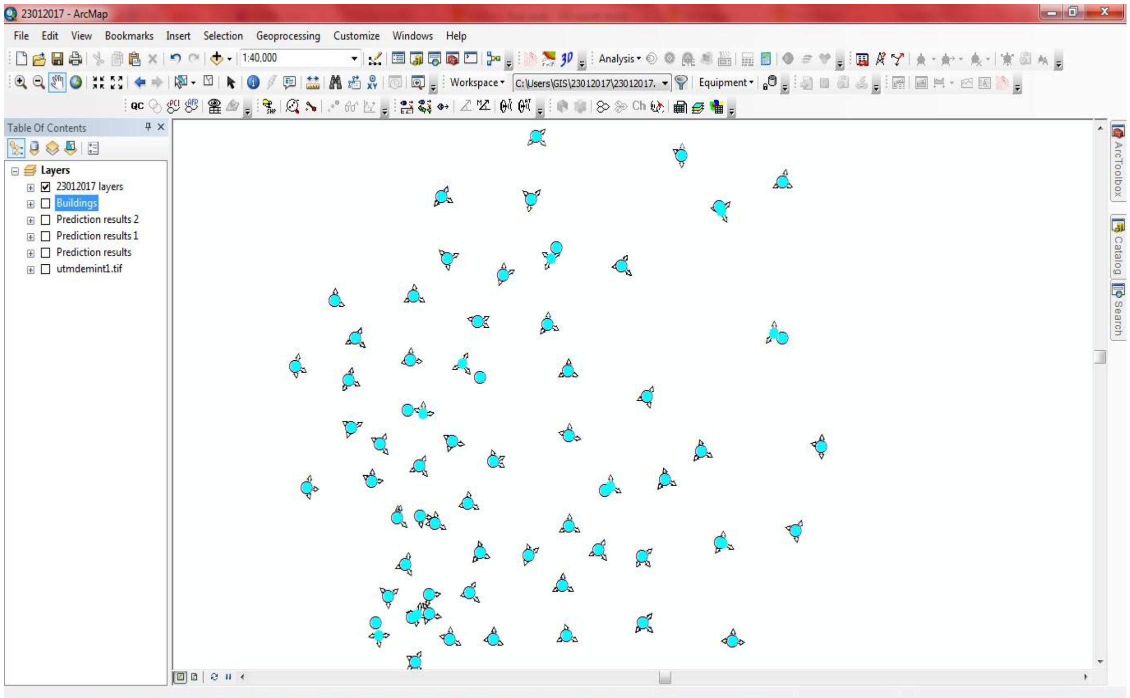


Figure (4-5): Describe the distribution of the antennas for X Telecommunication Company, each antenna represents one site and many sector directed to different direction.

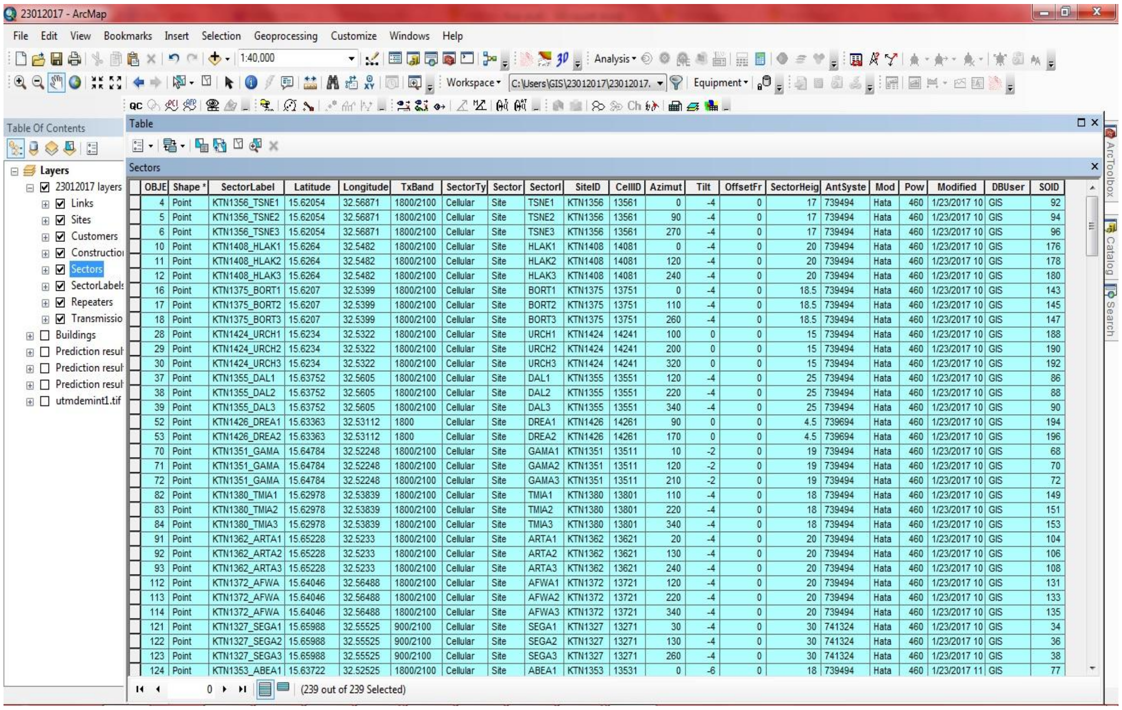


Figure (4-6): Information of all sectors that we use in the study area like the name of site that belongs to, base height, max radius and sector direction.

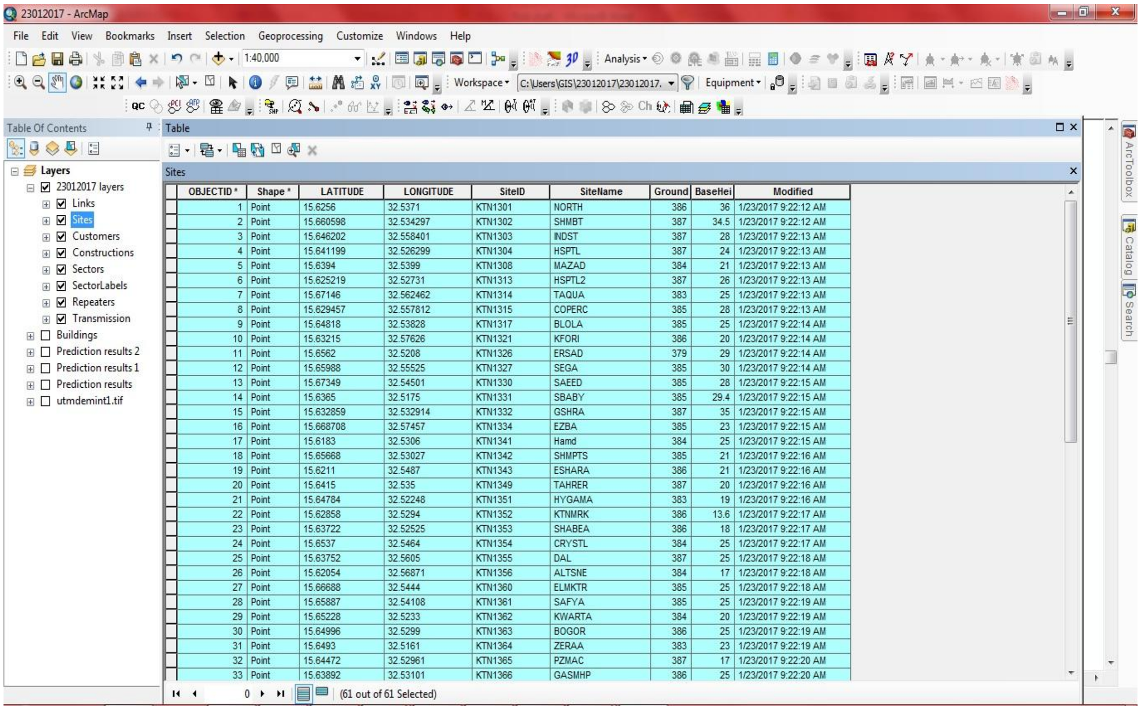


Figure (4-7): Information of all sites that we have , information like site name, max radius, latitude, longitude, technology and height above the ground.

Chapter 5

Results and Discussion

Chapter 5

Results and Discussion

5.1 3D Coverage Prediction

In previous chapter we showed the case study of X telecom company based on that antennas and the 3D Model of specific area that we build , we enhanced the quality of service for mobile network using Cellular expert tools to calculate the prediction base on field length and best sector as shown in figure(5- 1).

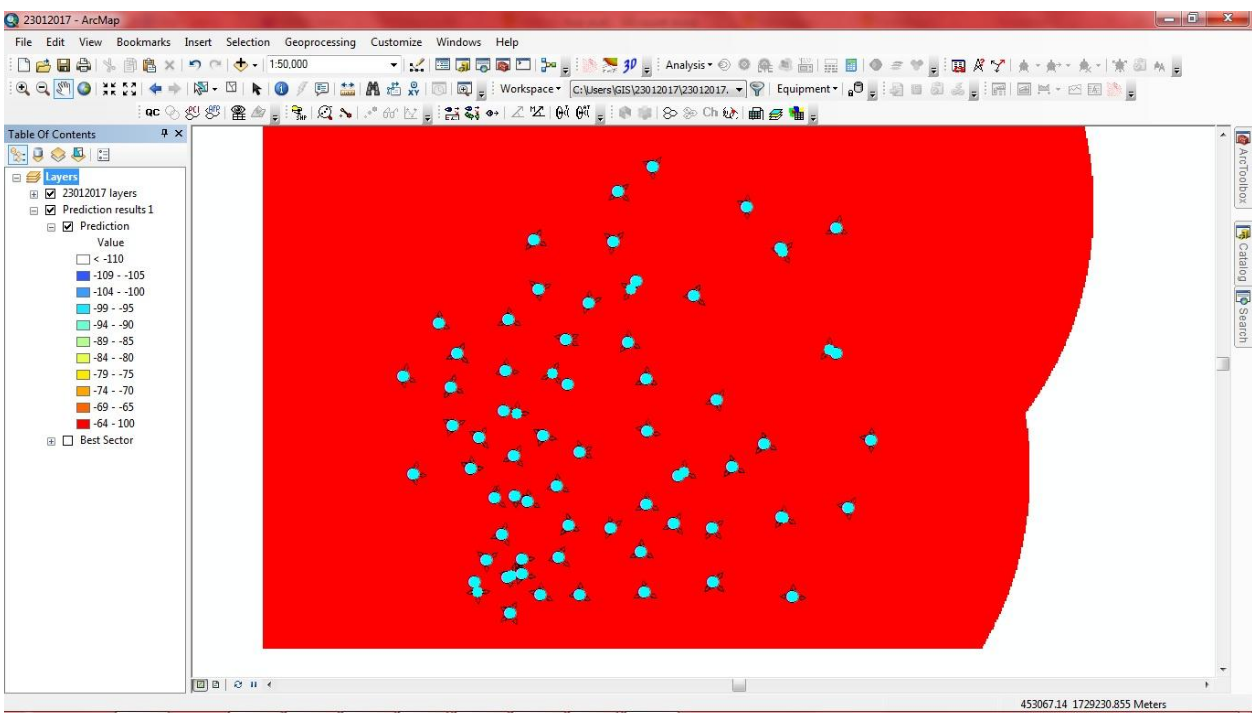


Figure (5-1): shows, which site has the strongest signal in that point.

5.2 Multiple Sector Direction

Using ArcMap with Cellular expert tool can calculate the optimal antenna direction (tilt and azimuth) for more than one sector at once, to enhance the quality of service of the real mobile network, as shown in figure(5- 2) there are many values of the old and after calculation for both azimuth and tilt.

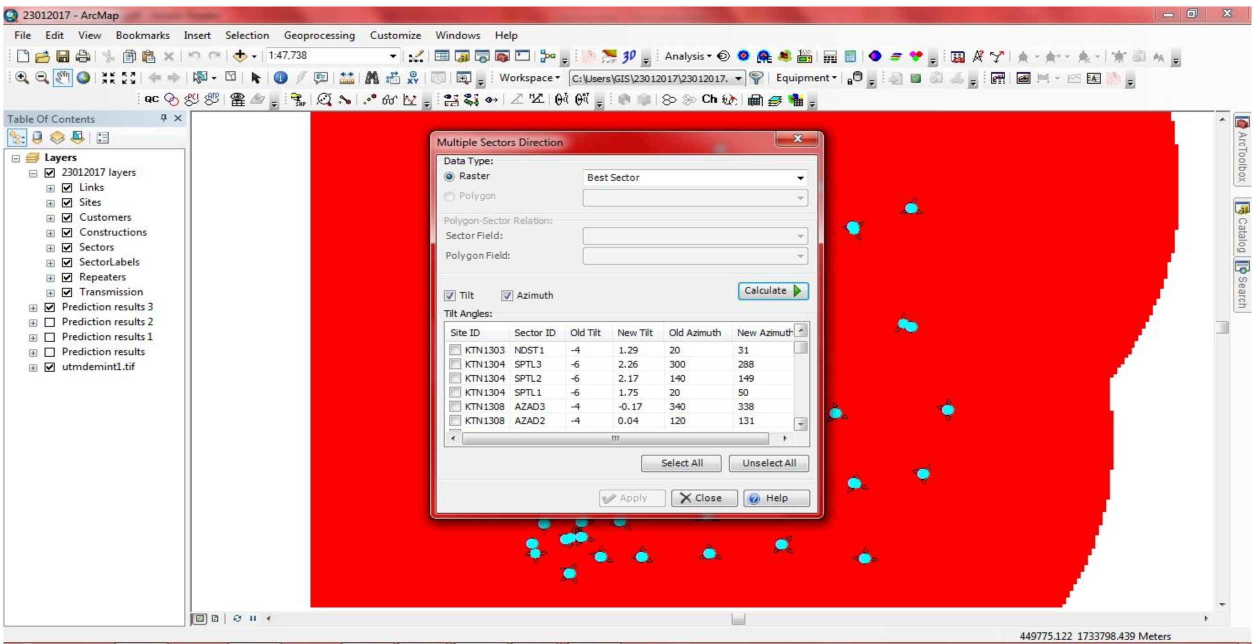


Figure (5-2): **Tilt** to calculate optimal tilt angle for each sector and **Azimuth** to calculate optimal tilt azimuth for each sector.

Chapter 6

Conclusions

Chapter 6

Conclusions and Outlook

6.1 Conclusions

From this research we have learned about GIS and extension tools, as well as 3Dmodeling, when used in enhance QoS with the existing antennas. By the end of this research the tasks have been achieve successfully.

In this project we have improved the antennas coverage using 3D modeling techniques applying ArcGIS tools and Cellular Expert software to simulate antennas positions and to calculate the intersection of signal transmission with obstacles. Before accomplished the previous task we have build a 3D map using ArcScene for level of detail 1 (LoD1) model for buildings.

Chapter 7

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