On The Feasibility of IEEE 802.22 WRAN Based Broadband For Rural Bangladesh -

Network And Coverage Planning

A thesis
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DECLARATION

We, hereby declare that this thesis is based on the results found by ourselves. Materials of work found by other researcher are mentioned by reference. This Thesis, neither in whole or in part, has been previously submitted for any degree.

Signature of Supervisor	Signature of Author
Rachean Mahfuz Huq	Rafi Rahman
	Farhat Nizam Ayon

ABSTRACT

Wireless Regional Access Network (WRAN) is progressively turning into the center design for next rural and remote zone access networks throughout all over the world. In the process, WRAN, which saves money on consumption and license costs, has expanded scope range, expanded cell capacity and uses unused or idle television spectrum, was recognized as a reasonable broadband access contender for giving availability of network to the provincial territories of Bangladesh. In the present days, internet has become a vital option for the mass people of Bangladesh. Moreover through this system, it becomes very easy to promote e-health projects to the people of pastoral area at a very less cost. Besides, people will get the access to internet at low cost. An outline system structure appropriate for rustic regions in Bangladesh is proposed and a fundamental cognitive radio (CR) simulation (based on IEEE802.22 WRAN) to demonstrate the possibility of outfitting unused or idle spectrum of Bangladesh television channels or frequency bands utilizing CR technology was an effective run. Power spectrum density estimation model for sensing was used. Various execution difficulties, for example, the impact of antenna aperture height on the concealed terminal issue are here talked about.

ACKNOWLEDGEMENT

We would like to thank our supervisor Mr. Rachaen Mahfuz Huq for his constant support towards the successful completion of the project. We would also extend our gratitude towards all the faculty members of the EEE department of BRAC University for their support in different course-works towards our degree.

We also want to acknowledge our fellow thesis group who were in charge of the theoretical design counterpart of this WRAN project: Arifa, Foysal and Omar. They have been very supportive in complementing our work, and we really enjoyed working with their collaboration.

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I. Introduction

The advancement of present day's wireless communication systems and the redesign of existing framework requests for higher throughput and higher mobility which are tested by radio scarcity in allocated spectrum range. As of late, there have been developing interests in cognitive radio (CR), where a transceiver can intelligently detect which communication channels are in use and which are not (White Spaces) and instantly move into vacant channels while avoiding occupied ones and adjust their radio parameters appropriately [1].White Space means the unused television frequencies in the wireless spectrum. Broadcasting companies leave crevices between channels for buffering intentions and this space in the wireless spectrum can be utilized to convey far reaching broadband internet [2]. CRs are imagined to have the capacity to give the high data transfer capacity to the clients by means of heterogeneous remote designs and element range access systems. CR mainly works with the IEEE 802.22 standard for WRAN (Wireless Regional Area Network) using white spaces in digital television frequency spectrum. In response to a Notice of Proposed Rule Making (NPRM) issued by the U.S. Federal Communications Commission (FCC) in May 2004, the IEEE 802.22 working group on Wireless Regional Area Networks was formed in October 2004. Its project, formally called as Standard for Wireless Regional Area Networks (WRAN) - focused on constructing a dependable, national fixed point-to-multipoint WRAN that will use UHF/VHF TV bands between 54 MHz and 862 MHz. Specific TV channels as well as the guard bands of these channels are planned to be used for communication in IEEE 802.22 [3].

II. Motivation

The main motivation for this work is most of the rural areas of our country is not getting high speed internet connections. The main reason is that the telecom operators are focused for covering the area where population density is higher. And in our country the mostly dense areas are the urban areas. For this reason the telecom operators are setting up more and more coverage tower in the city areas. As a result, the rural areas are falling behind. Most of the rural areas are now still under 2G network coverage where the data rate is 9.6Kbps (GPRS) to 200Kbps (2.75G) whereas the data rate for 3G connections is 2 Mbps-10 of Mbps [4]. As all of the companies are owned by different multi-international companies (except Teletalk), they are not willing to setup new coverage antenna in those areas where population density is low because this will cause a great loss for them as the number of active users will be very less. Besides, it is also quiet impossible for any new company to penetrate in the market buying a new spectrum range and continue their business. So, we are proposing to introduce cognitive radio where we can use the TV white spectrum and transmit internet connection to the furthest corner of Bangladesh covering all the rural areas.

III. Existing Technologies

There are various recorded research papers on conceivable methods for giving internet connection to rustic regions utilizing existing technologies. These innovations conveyed incorporate the utilization of Cellular (2G & 3G), WIMAX as for examples. These advancements have their advantages and disadvantages yet the real downside for every one of them relies on the affordability of the end client to take up the services; for the rural market these systems would be unviable thus unsuitable for rural territories as most of them are expensive and mostly there is a problem regarding coverage. However new courses keep on being looked for with a specific end goal to connect the monetary gap utilizing blends of these current advances.

IV. Major Definitions

Array Factor:

N number of identical Omni-directional (faced in same direction) Antenna usually defined as the array factor that follow similar pattern. Because of array factor we can combine multiple antennas that help in transmitting and receiving of signal.

Broadside Array:

It is a typical collinear antenna that consist half-wave (1/2 wavelength) dipoles. It directs maximum radiation which is perpendicular on the plane of its array. Basically, Broadside array is bidirectional with narrow beam width and it has high gain.

CPE:

Customer Premises Equipment (CPE) is none other than our telecommunication service provider equipment that placed in customer's devices rather that the provider's physical location. The devices are the equipment we use for communication like: telephone, mobile, set up box for cable TV, router, modem, VOIP base stations are basically the examples of CPE. However, Most of the CPE owned by the service provider except modem, router that bought by the customers. In our project we used end-fire array to design Customer Premises Equipment (CPE).

Cognitive Radio Technology:

Cognitive Radio (CR) systems bring into focus another method for taking a gander at wireless communication networks. Given the way that the known frequency spectrum is waning rapidly, the need to productively use this extremely restricted and costly asset turns out to be more urgent. In Bangladesh, the use of radio spectrum assets and the regulation of radio emissions are the functions of the Bangladesh Telecommunication Regulatory Commission (BTRC) which is in charge of appointing spectrum to particular license holders as per the static spectrum assignment policies. It was watched that spectral assignments by this strategy leave huge segments of the allocated spectrum underutilized. In this way, inside a TV authorized range, some TV channels are vigorously utilized at specific times, while others are to a great extent empty for the greater part of time. The empty channels are alluded to as voids which could get to be accessible sharply for different employments. Cognitive radios are characterized as it will intelligently identify portions of the spectrum that are idle at a particular time and/or area, prompting the best spectrum and proper working parameters being chosen [5]. It is this trademark which is referred to as re-configurability that is used in WRAN for the opportunistic access of the TV frequencies for connectivity in remote and rural areas [6]. IEEE 802.22 standard is favored for two principle reasons: (i) no dedicated spectrum is required, as a result service providers can save money on spectrum permit expenses, and (ii) a wide coverage area; a radius of minimum 33 km that can be expanded up to 100 km [6][7]. This is vital keeping in mind the end goal is to achieve an extensive client base in rural areas. The System design of WRAN is a straightforward point to multipoint framework in which a WRAN base station (WRAN BS) serve multiple fixed-location wireless customer premise equipment (CPE) and an associated TV station. Equipped with a directional antenna for communication with BS and an Omni-directional antenna to sense and measure the wireless environmental condition, the CPE is capable of adapting and to timely change the transmission characteristics as necessary in the face of primary user activities.

End-fire Array:

It is organized in a linear or cylindrical antenna array that directs most of the radiation in the direction of the axis. In this project we used half-wave horizontal dipole of end-fire. In end fire array many identical antennas are used with equidistance manner. It can be unidirectional or bidirectional radiation pattern.

IEEE 802.22 WRAN:

IEEE 802.22 WRAN is the first IEEE standard for operation in TVWS. It involves the frequency sharing among different operators to operate in the free channels in TV broadcast spectrum using CR technology. The network has to operate in a point to multipoint (P2MP) basis where BS and CPEs will be linked with wireless connection. The BSs will control the medium access for all the CPEs. WRAN BS is capable of cognitive sensing. The CPEs sense the spectrum and send periodic reports to BS informing their senses. Based on the reports sent by the CPEs, BSs will evaluate whether there any change in channel is needed or not. The bandwidth should be adjusted dynamically so that with different conditions the BSs can switch the channels without transmission errors and without losing connection to the CPEs. The radius of one cell should be from 30 km to 100 km. The frequency should be from 54 MHz to 862 MHz. And most importantly the data transfer rate is 1.5 Mbps in downlink and 384 kbps in uplink [8].

Radio-Mobile Tool:

Radio Mobile is a Free Radio Propagation simulation program which works over the frequency range of 20MHz to 20GHz. It totally depends on the ITS (Institute for Telecommunication Sciences, Longley-Rice) engendering model. The program enables the elevation maps to be drawn of specific areas using downloaded SRTM data from the Space Shuttle Radar Terrain Mapping Mission, elevation curve and road maps to be added and Radio Units (base stations) specified for performance and placed where they are required. Individual Radio Unit performance is specified as a Radio Operating 'System' for transmission power, sensitivity, antenna parameters etc. and all 'Radio Links' between Units can be examined for path profile and signal parameters [13].

TV White Space:

TV white space is usually the unlicensed broadcasting frequencies that remain unused (not used for television broadcasting). There is a space that placed between TV channels for buffering it like guard band. That free wireless spectrum is defined as white space. Similar type of spectrum is used 4G network that is why we can use TV white space for broadband internet. This spectrum is placed in VHF (very high frequency) and UHF (ultra high frequency) range is 470MHz to 790MHz.

V. Previous Work

White Space broadband can possibly reform the way we get to the web, particularly for those in provincial zones, where there is abundant free, unlicensed White Space spectrum to use. There is very little White Space spectrum accessible in densely populated urban areas, where more people are utilizing more TV channels and there are more television stations. The innovation is moderately new and questionable, so most arrangements are still in trial stages. About ten (10) trials are occurring regarding giving connection to the libraries, public places and schools.

In 2012, almost three years after the FCC proposed the primary White Space business system in Wilmington, North Carolina, the city at long last implemented this project. The venture is run through Spectrum Bridge, one of the main FCC-affirmed White Space databases, and Wilmington was picked on the grounds because it was the primary city to the change from analog to digital TV, which authorized the wireless spectrum for White Space. Since the project started, the government is utilizing the system to connect two local parks and a few public gardens, supervise water levels, water quality, and public lighting. The city was likewise a pilot area for testing White Space gadgets to be affirmed by the FCC for business use [9].

The Pascagoula School District, Mississippi, after the Hurricane Katrina, needed to have White Space technology accessible as a disaster recovery resource. The venture was intended to expand internet access for the mass people i.e. for the community. The community built a moveable unit comprising of a tower and telescope. It can be moved for community occasions, whether that is a county fair or a show, or on account of crises, turn into a transportable Wi-Fi hotspot. Pascagoula additionally plans to utilize the technology to supplant a DSL connection in an Adult Learning Center, which will triple the bandwidth capacity and lower the month to month bill [9].

From the Delta County libraries system, five libraries serve 30,000 individuals. The principle White Space device was set up in a library in Paonia, Colorado, a town of around 1,500 people. The Gigabit Libraries Network pilot started in October 2013, however amidst the trial, the county cut the financial plan. The people thought they would need to give the gears back and stop the White Space pilot. The hotspots in Paonia, downtown and in the park, utilized digital radio equipment from Carlson Wireless and Wi-Fi access points from Cisco Meraki. However, to wrap up the project, the town sorted out a Kick starter campaign, endeavoring to raise $4,000. With 63 benefactors from the community and somewhere else around the country, it was funded in 30 days [9].

The pilot tests in Philippines for White Space broadband are the most costly in Asia. As per Means, the nation is a perfect area to test White Space broadband, with its thick foliage, remote areas, and far reaching villages. The pilot tests began after the Bohol earthquake and Typhoon Haiyan (Yolanda) in 2013, and gave basic catastrophe alleviation and allowed data to be sent all through the influenced areas of Bohol and Leyte areas in the Visayas [9].

After pilot ventures through the Microsoft 4Afrika activity in Tanzania and Kenya, the organization actualized a White Space venture in the Limpopo territory in South Africa. It interfaces schools in rustic regions and utilizes solar powered base stations to control the system. The principle base station is on the University of Limpopo campus. Google was the primary significant player in the nation, sending a comparative project for 10 local schools in Cape Town in 2013. The town is encompassed by hills and mountains, so there are three transmitting antennas to transmit the wireless broadband internet. The main base station utilizes a 10 Gbps connection [9].

In April 2013, White Space touched the ground of "Gold Country" El Dorado County, California, when Carlson Wireless joined forces with Cal.net, a northern California internet service provider, to convey internet to segments of the territory. Carlson's RuralConnect, which is conveyed in a few territories around the US, conveys broadband connection by transmitting over TV White Space frequencies ranges from 470 to 698 MHz [9].

The Singapore White Spaces Pilot Group, which includes organizations, for example, Microsoft, Adaptrum, Spectrum Bridge, and Grid Communications, has conveyed three ventures that show the administrations White Space can offer. The three ventures are: (1) National University of Singapore (2) Singapore Island Country Club (3) Changi district adjoining the airport. At this moment the internet is costly, so this test case project is being utilized to decide how to decrease those costs [9].

Strathclyde University's Center for White Space Communications in Scotland is a pioneer in exploration on White Space broadband. The Isle of Bute facilitated an 18-month venture beginning in 2012 that was the first of its kind in the UK. The trial gave Wi-Fi access utilizing White Space spectrum to eight homes on the south part of the Isle of Bute, which already had no entrance to the internet [9].

Libraries in Kansas City are trying White Space for a four month pilot, conveying Wi-Fi in public libraries in remote areas of the city. The Kansas City K-20 Libraries activity is cooperation between academic, school, and public libraries that is attempting to spread internet access over the society [9].

Faculty and students on West Virginia University's (WVU) campus in Morgantown, West Virginia have Wi-Fi availability on Personal Rapid Transit platform through a White Space broadband task. More than 15,000 riders come to the campus each day utilizing electric-controlled vehicles. This was the first step launched via Air.U, whose objective is to convey

White Space to university areas. At WVU, 12 Mbps broadband can travel more than two miles through one TV channel [9].

VI. Problem Area

Till now we have come to know about 10 (ten) projects which are now ongoing to give broadband internet coverage to the different parts of the world. All of them are now in the trial stage. The main problem regarding giving internet connection via TVWS is the cost efficiency. All the connections cost more comparing to the other internet services. Besides, most of the trials were made in the urban areas. So, for the people of urban area it is not a problem in most cases. But our main target is to give broadband connection to the remote areas. If the cost per connection is too high, then people of rural areas will not be able to take the connection in their home. And if the cost cannot be lessen, then launching a new technology in a developing country like Bangladesh, will not bring a fruitful outcome.

VII. Research Gap & Contribution

On the context of WRAN, there is still no work or project undergoing in our country. So, we came up with the idea if it is possible to introduce CR in the context of Bangladesh. We have done the simulation using radio mobile tool to see the scenario by placing the base stations in the remote part of our country i.e. in the rural areas. We have showed that it is possible to introduce the CR using WRAN in Bangladesh. Besides, the cost for setting up this technology in our country will be very less comparing with the GSM technology setting up cost.

VIII. Research Question

The main research question of our thesis is how to use theoretically designed antenna arrays (coverage, P2P, and CPE) to evaluate the feasibility and for a WRAN based wireless broadband network in a given territory within the VHF-UHF spectrum, with the use of radio-planning software.

IX. Outcome of the Thesis

After completing our thesis work we come to a decision that on the context of Bangladesh introducing CR using WRAN with TVWS spectrum is a beneficial project which will give very fast broadband internet connection to the remote part of Bangladesh i.e. in the rural areas.

X. Summary of the Chapters

Here we have showed the working principle of a new technology named CR with the help of IEEE 802.22 WRAN with the use of TVWS of our country. We have showed the simulation to show how the BS would be transmitting the signal for connecting with the CPEs after getting information from CPEs about the unused TV spectrum of a particular area. We also have talked about the economic efficiency for establishing the new technology.

XI. Methodology of Simulation

The CPE antennas for WRAN coverage will be designed apart from the selection of other antennas for coverage. Then each BS will be implemented with WRAN coverage so that 100 percent of the rural areas of Bangladesh can be covered under the coverage. In order to maintain the line of sight (LOS) between the neighboring BS, the task of designing P2P network should be done with care so that the Fresnel zone does not touches the ground or any high rise building. Then each data for coverage antenna and P2P antenna are noted down for the next stage of survey and data analysis.

XII. Simulation Analysis

For the simulation part of this task, we have used the Radio Mobile tool. As our main concern is to give coverage in the rural areas and to establish P2P network, we have divided the simulation part in the two segments.

1. Coverage Simulation
2. P2P Simulation

1. Coverage Simulation

Simulation for the coverage is obviously very difficult as there are many unknown variables such as the TV repeater/booster station transmitter power, total number of channels or frequency bands, actual environmental topography, sources of interference, number of prospective users etc. Hence the prime objective of this simulation is to show the possibility of harnessing idle TV channels/frequency bands using CR technology. In this methodology of simulation, we set the TV channel to be operated within 740 MHz to 796 MHz frequency band. Some of the TV channels will be assumed active with user data, while others will be without user data information, thus referred to as idle. The active channels are assumed allocated to primary users while secondary users opportunistically utilize the inactive spectrum. Bangladesh like many other developing countries has 24 hours TV transmission but transmits mostly in between 1400 and 2300 hours; which leaves TV channels mostly idle for the rest of the day. It is therefore assumed in this simulation that carrier frequencies operating within this time slot will be active; any other combination will be assumed inactive or idle.

For conducting this simulation we have taken some assumptions based on which we have configured the antennas for the coverage part. The assumptions are stated below.

For Coverage Antenna:

i. The frequency range 740 MHz to 796 MHz
ii. Transmission power 19 dBm (943282 x e^{-02} watt)
iii. Receiver threshold -107 dBm (1 µV)
iv. Antenna gain 2.16 dBi
v. Antenna height 20 m

For CPE:

i. Transmission power 19 dBm (943282 x e^{-02} watt)
ii. Receiver threshold -107 dBm (1 µV)
iii. Antenna gain 17 dBi
iv. Antenna height 10 m

For conducting this simulation we have used different types of antenna which were designed in MATLAB and were saved as .ant file so that the files can be used in radio mobile tool. This is the contribution of another group who worked for designing the different types of antennas which we are required to do the simulation. The radiation patterns and array factors plotted in MATLAB are stated below.

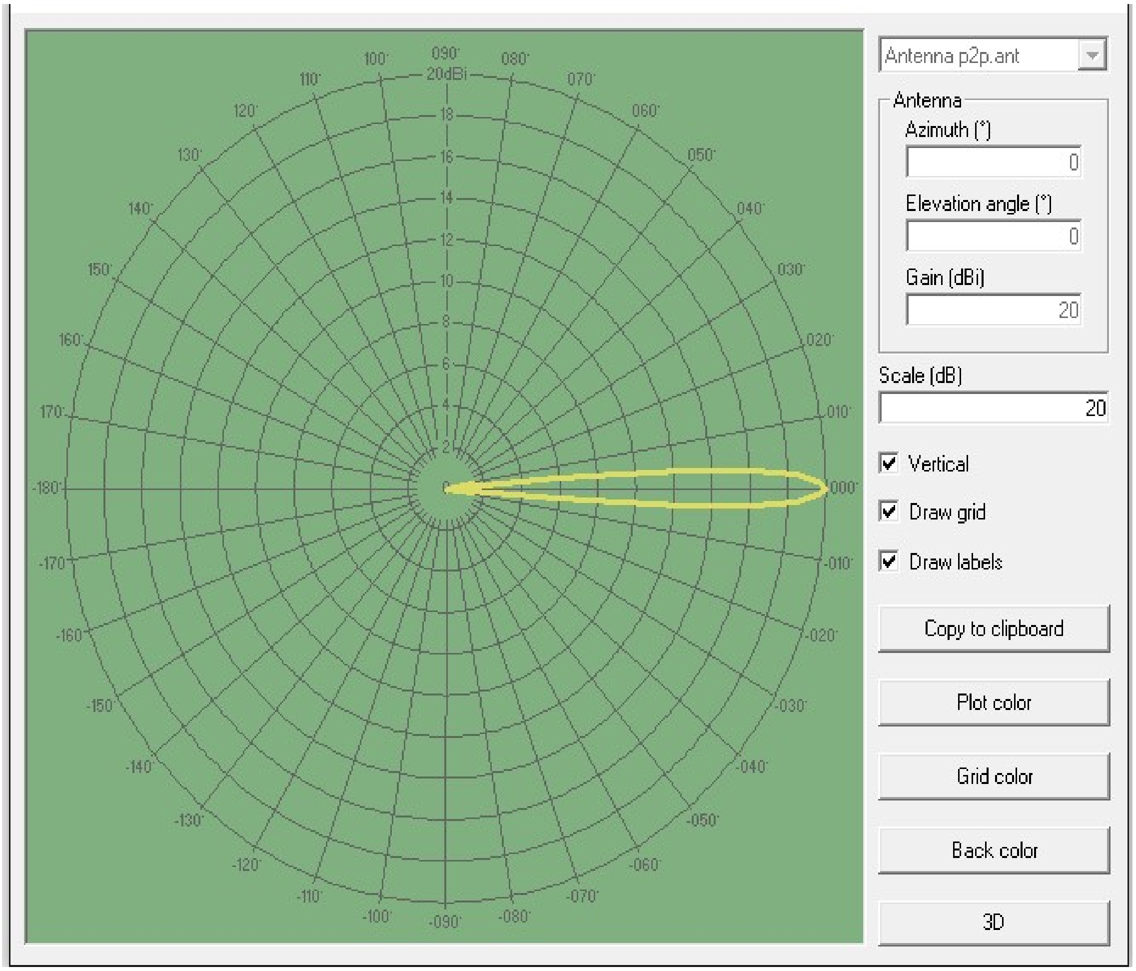

Figure 01: P2P antenna Radiation Pattern Vertical (only antenna/not array)

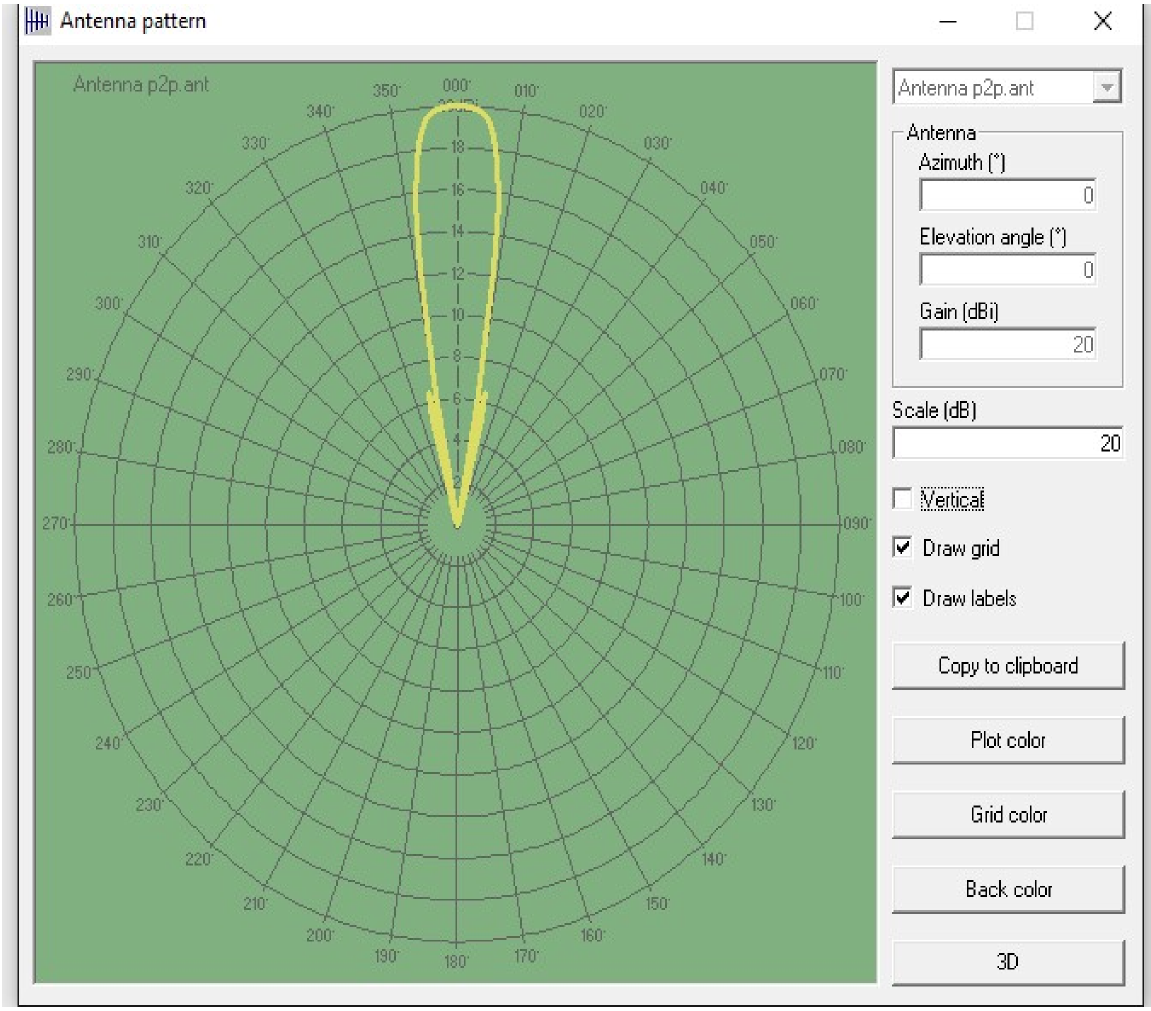

Figure 02: P2P antenna radiation pattern (horizontal)

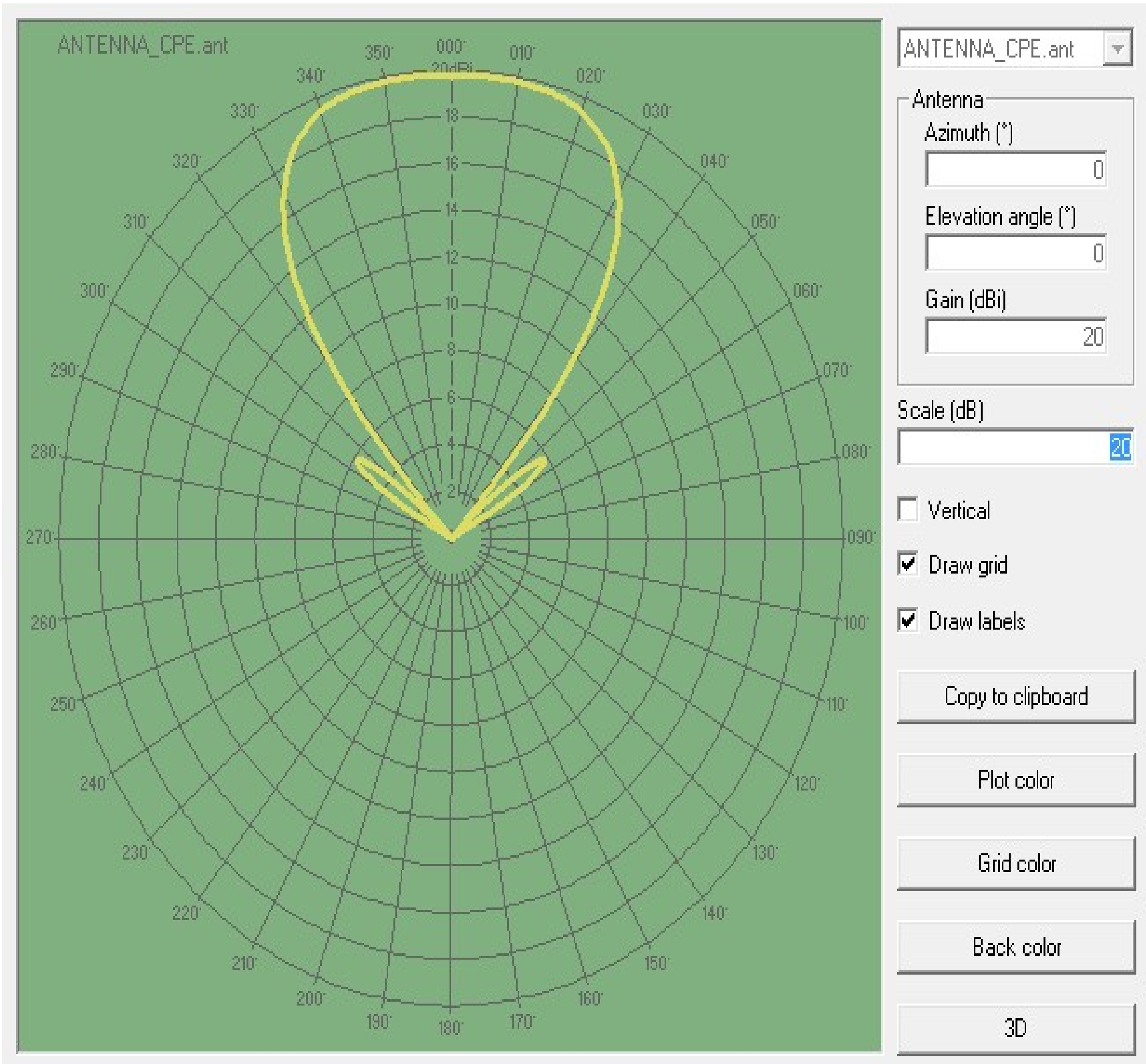

Figure 03: CPE radiation pattern (horizontal)

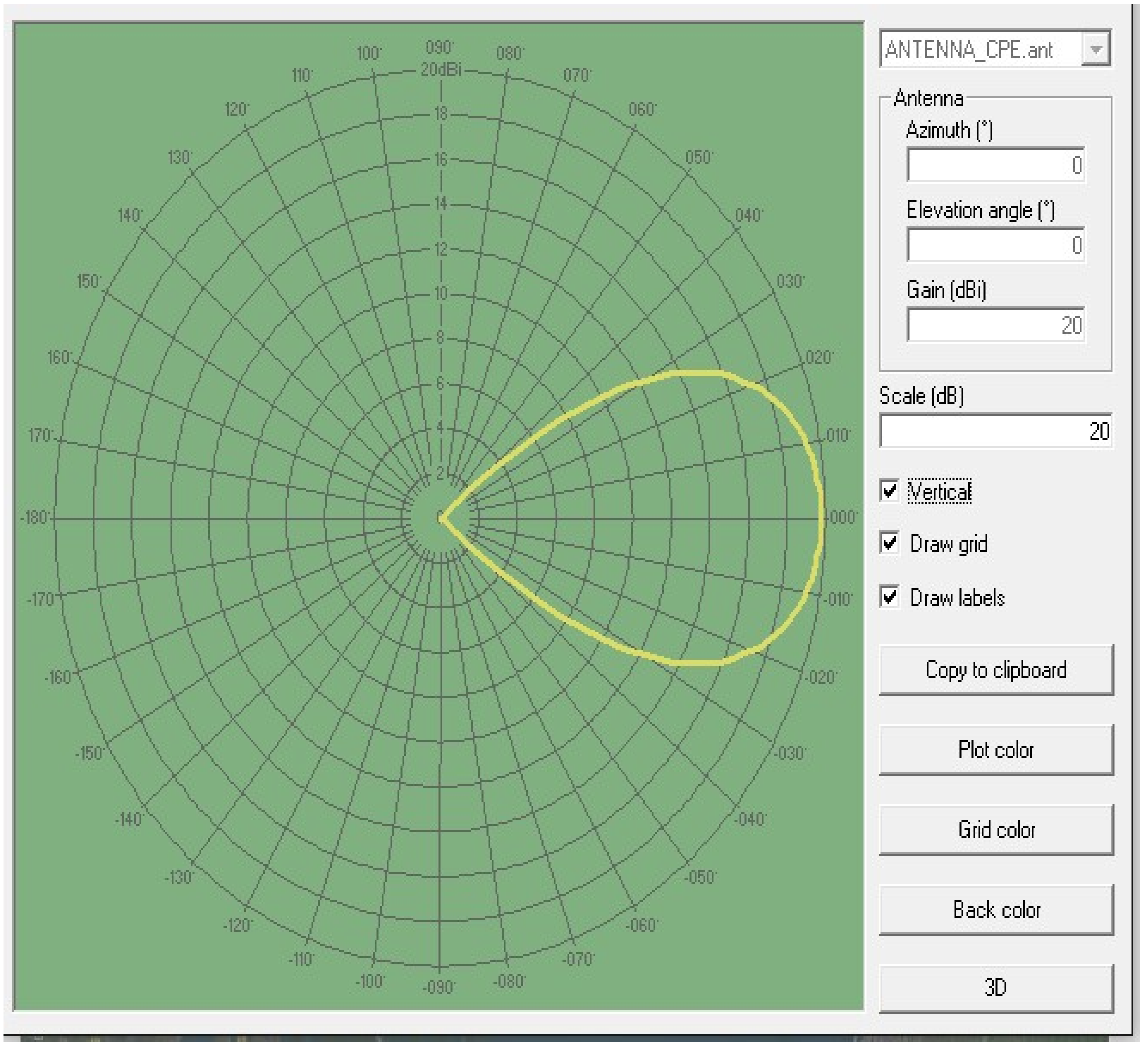

Figure 04: CPE radiation pattern (vertical)

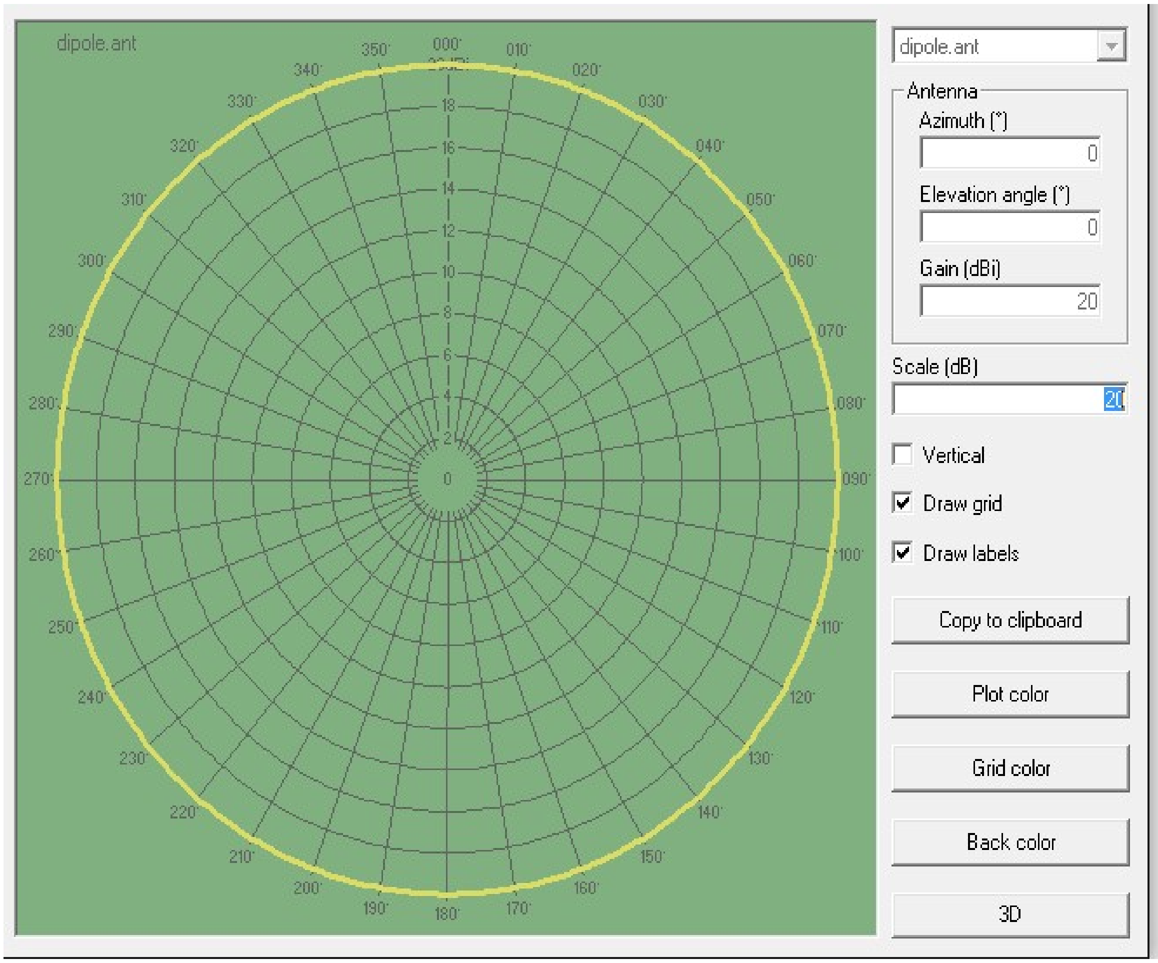

Figure 05: Dipole Antenna (used for coverage) radiation pattern (horizontal)

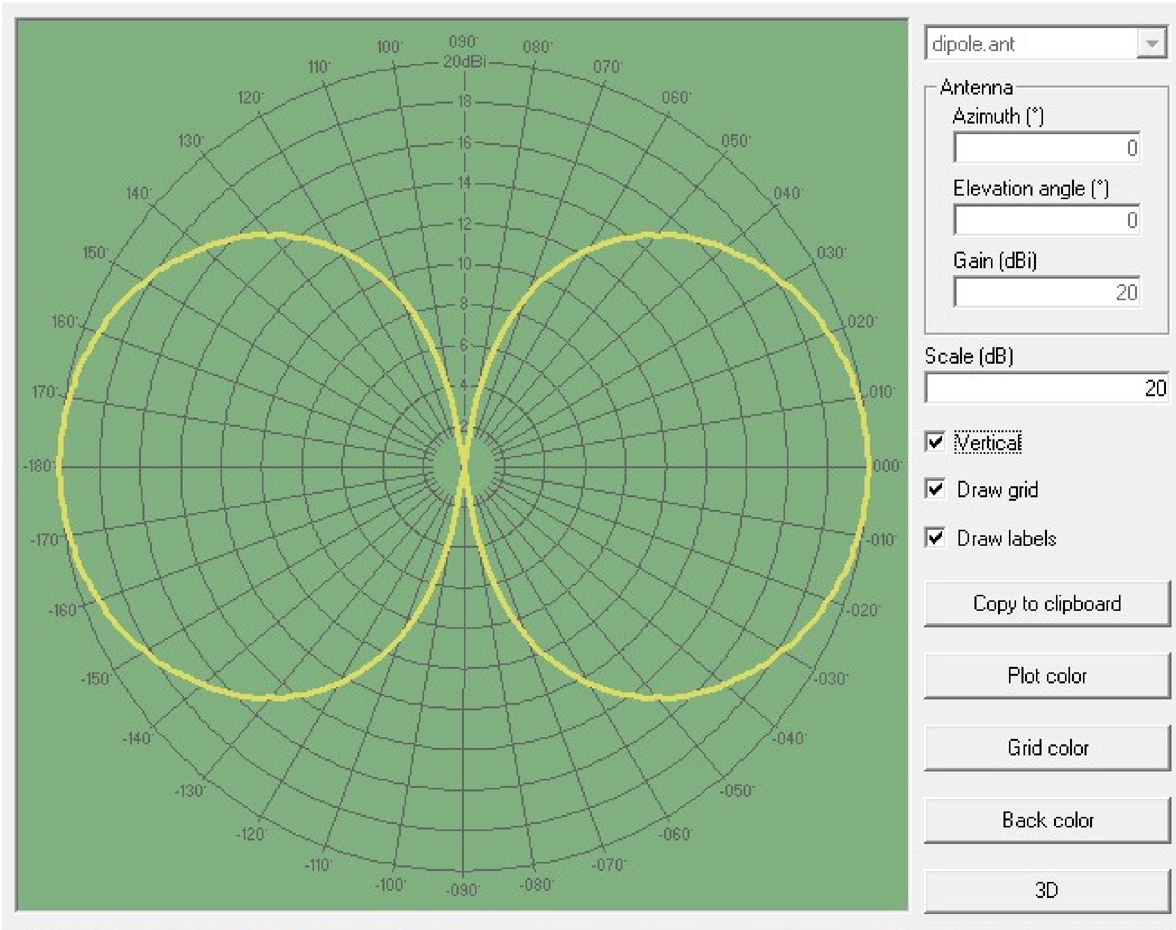

Figure 06: Dipole antenna radiation pattern (vertical)

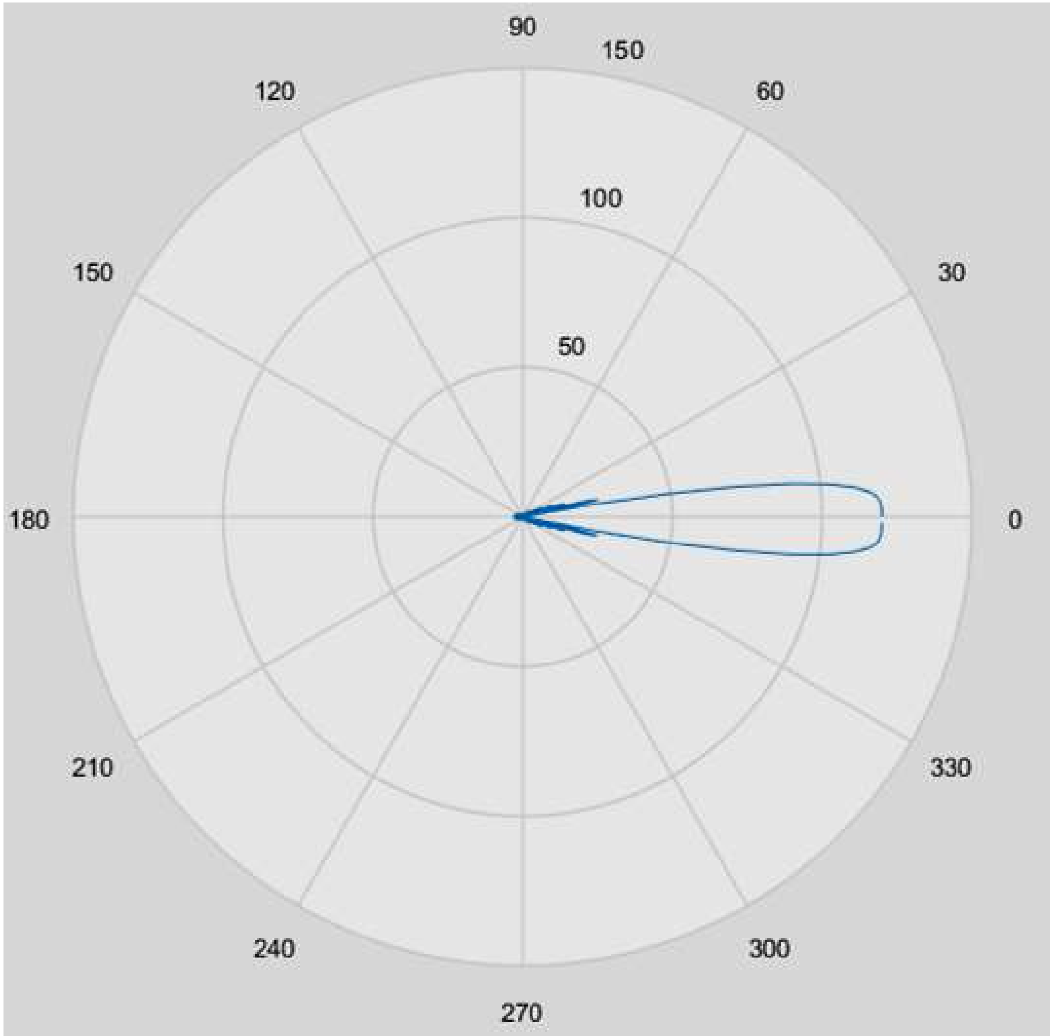

Figure 07: P2P Antenna Array factor (similar to radiation pattern just with the combined effect of the array) – horizontal.

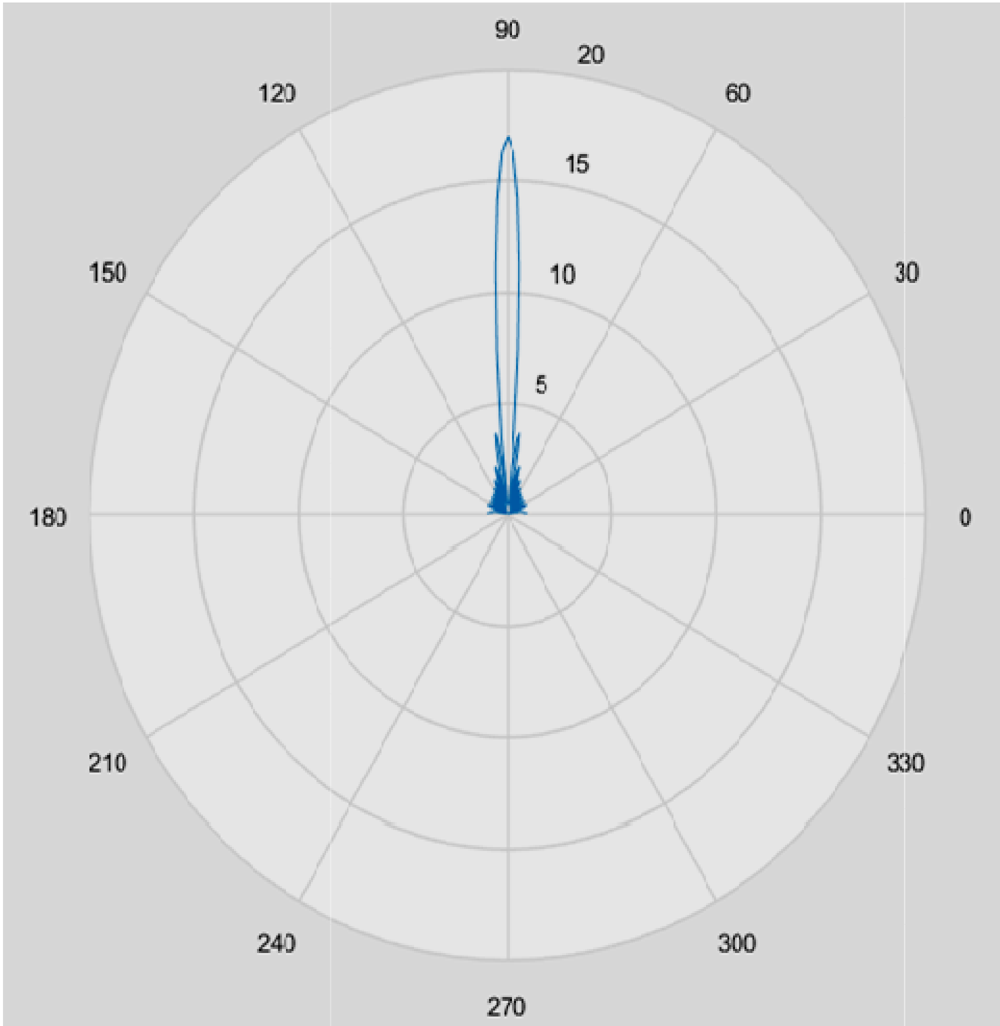

Figure 08: P2P Antenna Array factor (similar to radiation pattern with the combined effect of the array) – vertical

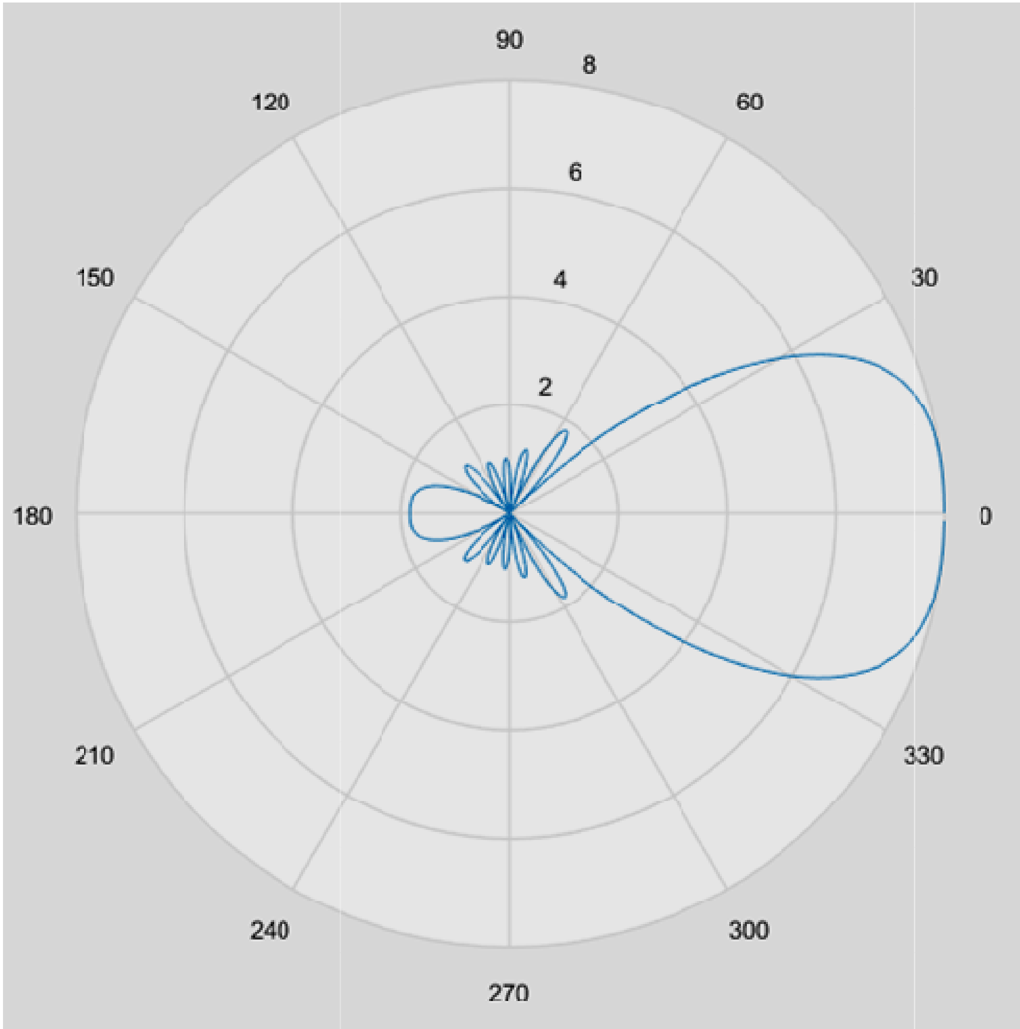

Figure 09: Array factor for CPE Planar Endfire Array (horizontal)

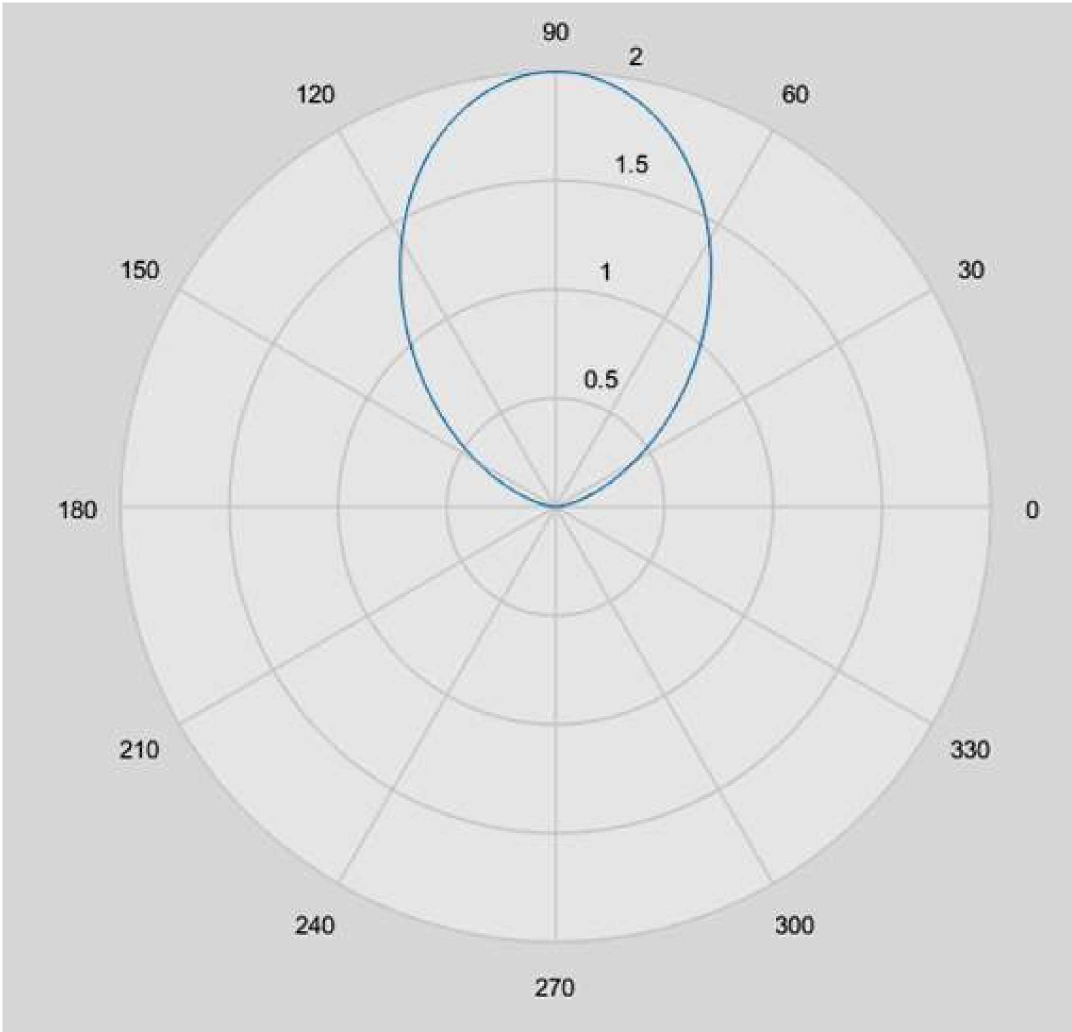

Figure 10: Array factor for CPE Planar Endfire Array (vertical)

The steps for the simulation using the radio mobile tool for coverage are pointed below.

1. At first from the "Network properties" tab, the coverage antennas are assigned with the assumption values. The antenna type is selected to the antenna_coverage.ant.
2. Then the values for the CPE are assigned.
3. After that from the "map properties", the latitude and longitude of our country is set. Then clicking the extract button will automatically download the map and is needed to be saved for further use of the map.
4. In the map, we have to set up the antennas at the top elevation of the specific area. For that, we have to select an area and then selecting "Find peak elevation" button will point the top elevation point of that selected area by placing a red cursor.
5. Then from "Unit properties" box, we have to select a coverage antenna and have to select "Place at cursor position". It will automatically send the antenna to the position.
6. Then from "Polar radio coverage" box, the "Centre unit" is to be specified to the coverage antenna and the "Mobile unit" is to be selected as CPE and the "Network" is selected as the Coverage Network. Then selecting "Draw" button will draw a coverage map centering the antenna.
7. Each time by selecting different "Centre unit" i.e. different coverage antenna, the coverage map for rural areas of whole Bangladesh is drawn. Then the map is saved.

For conducting the simulation, we have considered three scenarios based on the location and population density. For the variation of scenarios the plotting of antennas are different. The scenarios are

A. No Overlap
B. Low Overlap
C. High Overlap

At first we are showing the coverage map with only one antenna in the map of Bangladesh.

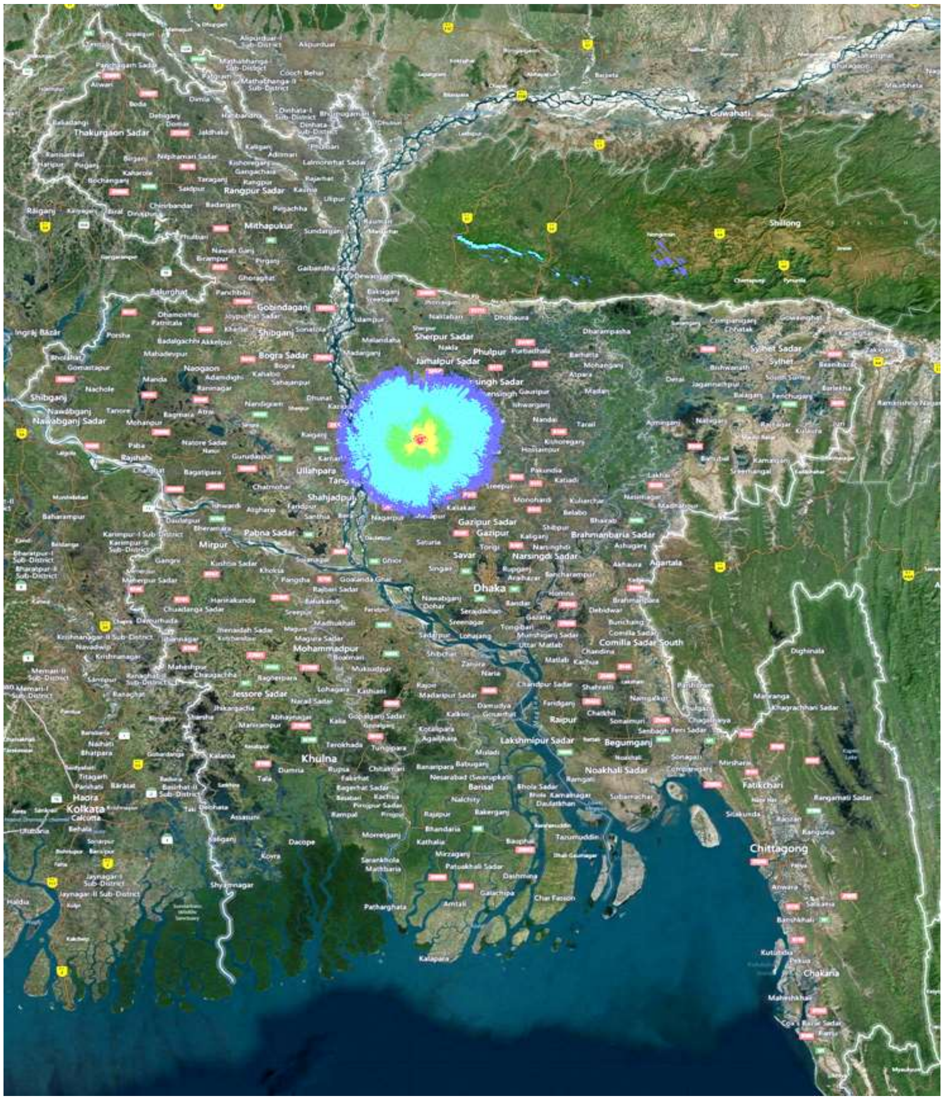

Figure 11: Coverage Map with One Antenna

The simulation for three scenarios is now described below with proper figure and table.

A. No Overlap:

For this case of simulation, we have considered that there is no high rise building in the rural areas and the population density is on average to every place of our experimented locations. This gives us the following coverage map and the data of every antenna is noted in the tabular form.

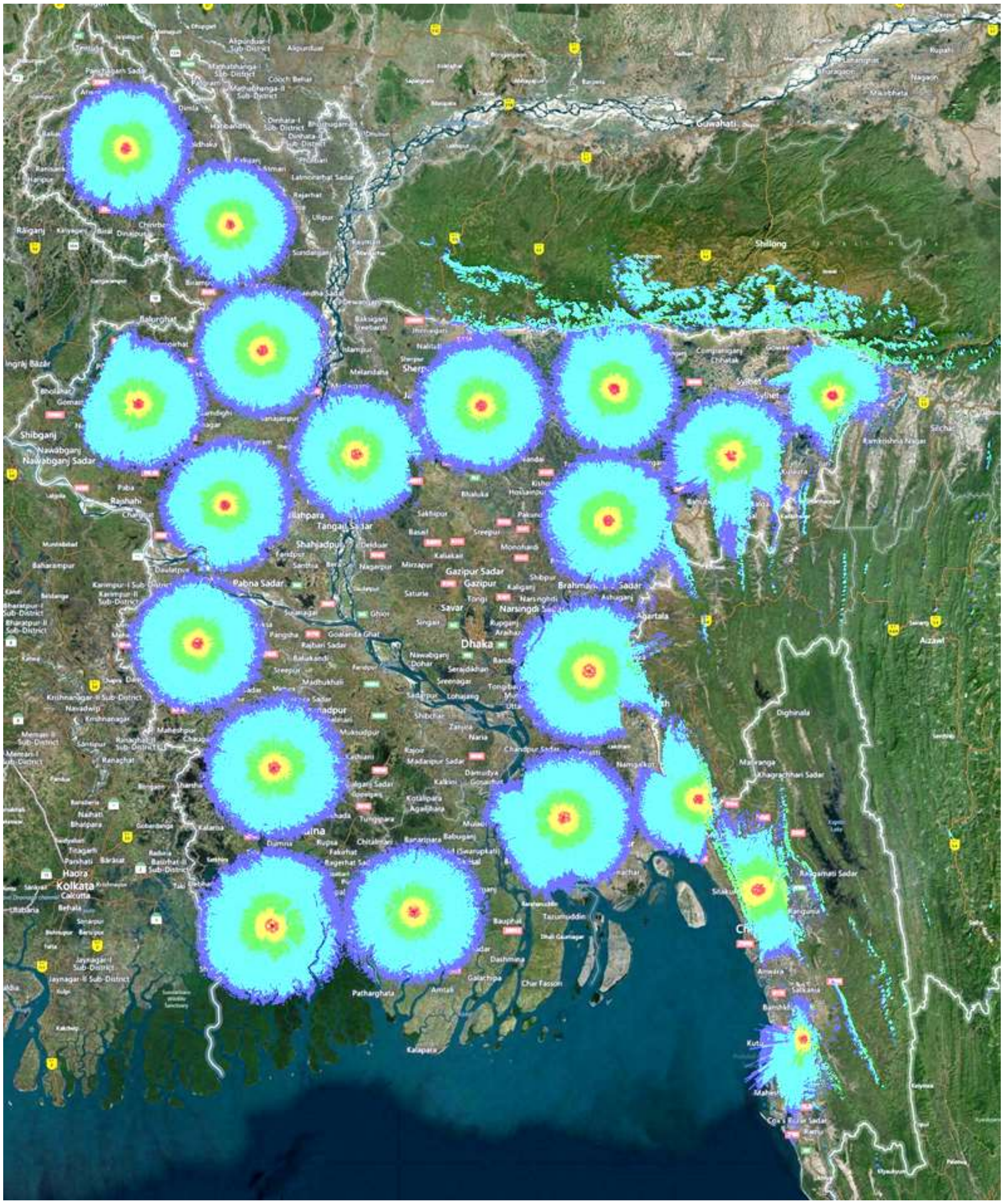

Figure 12: No Overlap Coverage Map

Antenna name	T_x power dBm	Area coverage (sq.km)	Elevation (m)	Antenna height (m)	Cell radius (km) $r = \sqrt{\frac{area\ coverage}{3.1416}}$
P2P25	19	5496	53	20	41.82
P2P24	19	4913	31	20	39.55
P2P23	19	5000	23	20	39.89
P2P22	19	4475	18	20	33.74
P2P21	19	4878	14	20	39.40
P2P20	19	5097	17	20	40.28
P2P19	19	5748	17	20	42.77
P2P18	19	6413	20	20	45.18
P2P17	19	5665	15	20	42.46
P2P16	19	5887	17	20	43.29
P2P15	19	5828	11	30	43.07
P2P14	19	6086	08	20	44.01
P2P13	19	6287	15	20	44.73
P2P12	19	4303	21	10	37.01
P2P11	19	5942	07	20	43.49
P2P10	19	6449	18	20	45.31
P2P09	19	5065	18	20	40.15
P2P08	19	2695	07	20	29.29
P2P07	19	2714	10	20	29.39
P2P06	19	2278	21	20	26.93

Table 01: T_x 19 No Overlap

→ Rajshahi Zone

→ Khulna Zone

→ Chittagong Zone

→ Sylhet Zone

B. Low Overlap:

In this case the simulation is done based on the present situation of our country. This simulation shows how the antenna should be established or set up considering the present high rise buildings and the current population density. This gives us the following coverage map and the data of every antenna is noted in the tabular form.

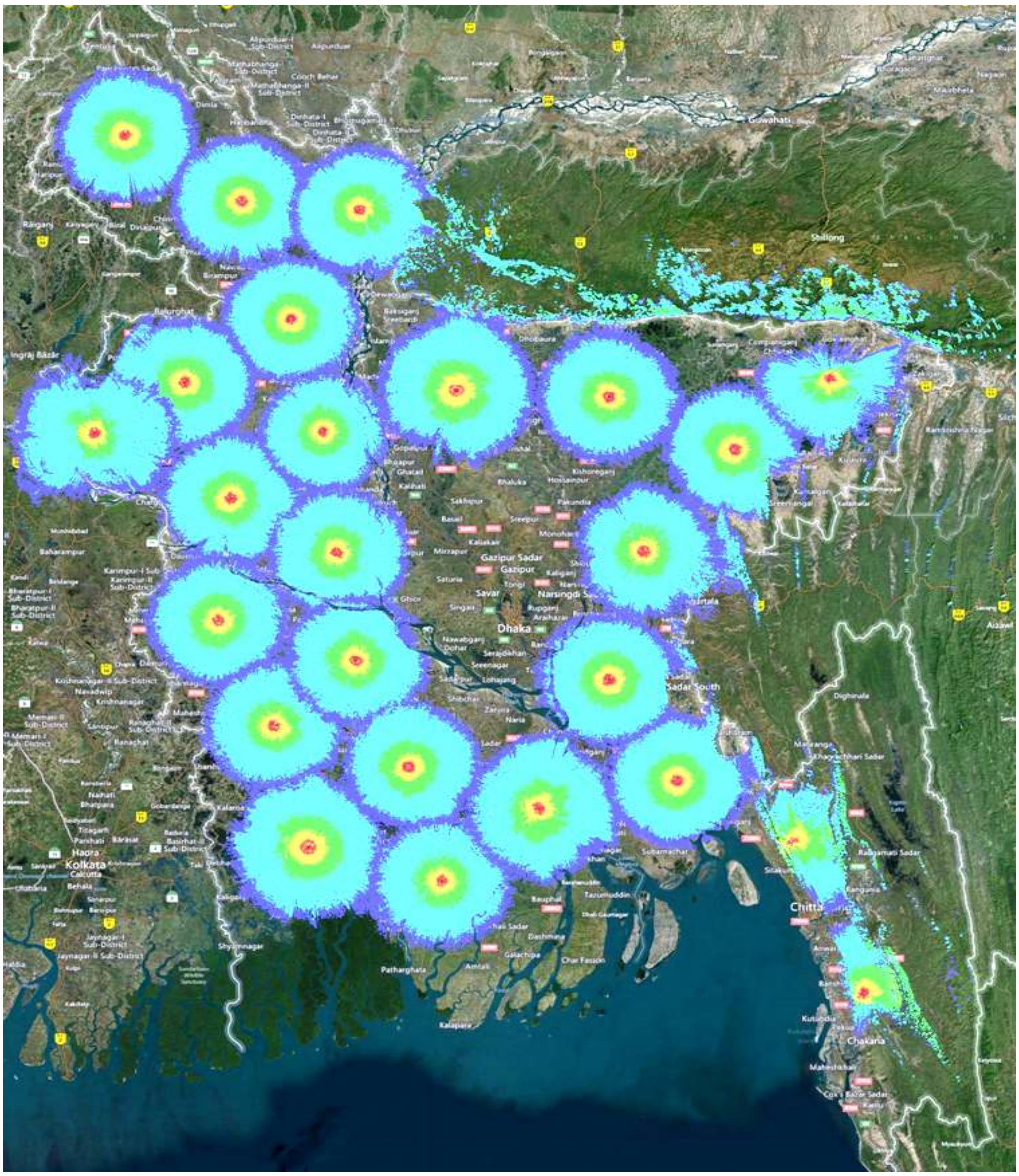

Figure 13: Low Overlap Coverage Map

Antenna name	T_x power dBm	Area coverage (sq.km)	Elevation (m)	Antenna height (m)	Cell radius (km) $r = \sqrt{\frac{area\ coverage}{3.1416}}$
P2P25	19	6018	60	20	43.77
P2P24	19	5375	37	20	41.36
P2P23	19	5005	23	20	39.91
P2P22	19	5204	19	20	40.70
P2P21	19	6262	44	20	44.65
P2P20	19	5238	19	20	40.83
P2P19	19	4445	13	20	37.61
P2P18	19	4947	12	20	39.68
P2P17	19	5578	26	20	42.13
P2P16	19	4933	16	20	39.63
P2P15	19	5102	12	30	40.30
P2P14	19	5189	14	20	40.64
P2P13	19	6360	10	30	45.00
P2P12	19	4851	04	20	39.30
P2P11	19	5251	11	20	40.88
P2P10	19	5961	15	20	43.56
P2P09	19	5377	12	20	41.37
P2P08	19	2483	28	20	28.11
P2P07	19	1796	21	20	23.91
P2P06	19	5115	11	20	40.35
P2P05	19	5927	10	20	43.44
P2P04	19	6532	11	20	45.60
P2P03	19	5622	25	20	42.30
P2P02	19	6443	13	20	45.29
P2P01	19	7121	22	30	47.61

Table 02: T_x 19 Low Overlap

→ Rajshahi Zone

→ Khulna Zone

→ Chittagong Zone

→ Sylhet Zone

C. High Overlap:

In this scenario, the simulation is done based on the future situation of our country. This simulation shows how the antenna should be established or set up considering the number of high rise buildings have increased and the population density is at its peak. This gives us the following coverage map and the data of every antenna is noted in the tabular form.

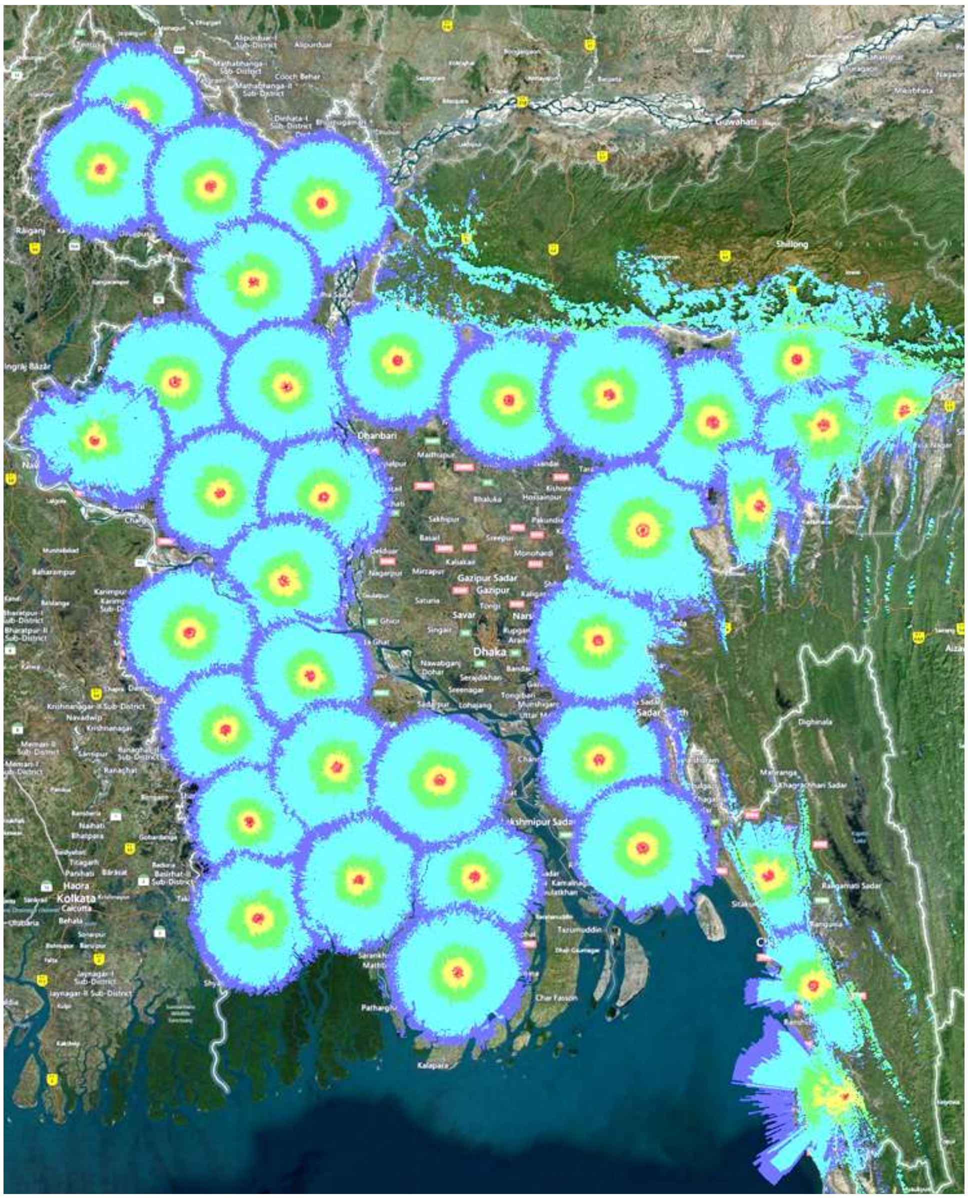

Figure 14: High Overlap Coverage Map

Antenna name	T_x power dBm	Area coverage (sq.km)	Elevation (m)	Antenna height (m)	Cell radius (km) $r = \sqrt{\frac{area\ coverage}{3.1416}}$
P2P40	19	5591	61	20	42.19
P2P39	19	5601	50	20	42.22
P2P38	19	5698	43	20	42.59
P2P37	19	6467	32	20	45.37
P2P36	19	5324	29	20	41.17
P2P35	19	5199	21	20	40.68
P2P34	19	5305	38	20	41.09
P2P33	19	5174	12	30	40.58
P2P32	19	4917	14	20	39.56
P2P31	19	4976	15	20	39.80
P2P30	19	5160	16	20	40.53
P2P29	19	5166	20	20	40.55
P2P28	19	4743	10	20	38.86
P2P27	19	4514	08	20	37.91
P2P26	19	4393	03	20	37.40
P2P25	19	5234	11	20	40.82
P2P24	19	5238	07	20	40.83
P2P23	19	5072	08	20	40.18
P2P22	19	4737	07	20	38.83
P2P21	19	5275	10	20	40.98
P2P20	19	5134	10	20	40.43
P2P19	19	4893	10	20	39.47
P2P18	19	5625	13	20	42.31
P2P17	19	5283	09	20	41.00
P2P16	19	2330	14	20	27.23
P2P15	19	3143	06	20	31.63
P2P14	19	4996	97	20	39.88
P2P13	19	6914	08	20	46.91
P2P12	19	7139	15	20	47.70
P2P11	19	4406	20	20	37.45
P2P10	19	5343	21	20	41.24
P2P09	19	3760	23	20	34.60
P2P08	19	3432	10	20	33.05
P2P07	19	5084	20	20	40.23
P2P06	19	6094	16	20	44.04
P2P05	19	6412	13	20	45.18

Table 03: T_x 19 High Overlap

→ Rajshahi Zone

→ Khulna Zone

→ Chittagong Zone

→ Sylhet Zone

After doing this simulation considering three different scenarios, we see that for no overlap situation we need 20 antennas to cover whole rural areas of Bangladesh with antenna height 20 meter for all excepting one antenna of 30 meter height and another one of 10 meter height. For low overlap situation, we need 25 antennas to cover whole rural areas with antenna height of 20 meter excepting three antennas of height 30 meter. And for high overlap situation, we need 36 antennas of height 20 meter excepting one antenna of height 30 meter. The maximum coverage area of an antenna is 7121 sq. Km and the minimum coverage area is 1796 sq. Km. The total area of coverage with the 25 antennas (low overlap scenario) is 132135 sq. Km which is 89.54% of total area of Bangladesh. The average coverage area with one antenna is 5285.4 sq. Km. As a result, the number of antennas required for covering the whole rural areas of Bangladesh using the CR is very less than the number of antennas used in the GSM technology for covering whole Bangladesh which is very much cost efficient in the perspective of a developing country like Bangladesh.

2. P2P Simulation

A point-to-point connection is a dedicated communication link between two systems or processes a very low-cost antenna is presented. P2P can be use for 802.22 (54 MHz-862 MHz) wireless local area network (WLAN) applications [12]. P2P antenna used as feeder for a standard TVSAT offset parabolic reflector, thus obtaining a high-gain antenna system configuration (Gain = 20 dBi) useful for point-to-point connections [10] [11]. Wireless internet connections also use point to point wireless in providing services to the customers. It is very easy to create point to point connections and it's also simpler to track any kind of signal interruption in point to point wireless connections. For those above quality we are using P2P connection for our simulation.

For establishing P2P network we have to understand the geography of Bangladesh. As we know, the geography of Bangladesh is flat on most of the regions and other regions are little bumpy near Sylhet and some at Chittagong. Our main target is to connect those hilly areas. To do that successfully P2P should be place perfectly to accomplish the high sloping locales of South Western regions of Chittagong. Additionally in the North Western area of Sylhet we could accomplish shorter than Chittagong yet at the same time sensibly long separation P2P interfaces however the primary goal was to associating the capital Dhaka. At first we began joins from P2P link antenna from Cox'sBazar, Chittagong coming towards Dhaka close by covering Mymensingh and gradually moving towards the north western sloping areas of Sylhet. Our aim was to cover Chittagong, Sylhet utilizing the way of grounds of these domains and in the way associates Dhaka and from Dhaka gives connections to urban communities in the northern locales of Dhaka so we can cover three most critical urban areas Chittagong alongside Sylhet and Mymensingh. Additionally, to give point to point arrange the significant obstacle was the level nature land in Dhaka and encompassing urban communities like Mymensingh, Jamalpur, Kisorgong etc. The obvious actuality is the greater part of the area possessed by Bangladesh is normally level. The ground height is to a great degree low in all parts of populated urban areas of Bangladesh. This is the reason the base of station for cellular telephone and different administrations utilize the tall structure to give their scope. In the country region they make isolate skyscraper tower to house their reception apparatuses. Since we don't have the building information in radio portable we cannot abuse that alternative. However, I would like make the relevant comment in the discussion. We can see from the system simulation, antenna need to put near each otherwise due to low Fresnel zone we can drop network quality. However the maximum number of allowed antennas is 50, we can cover more than half of the populace zone of Bangladesh, since the aggregate region of Bangladesh is impressive little.

The steps for the P2P link simulation using the radio mobile tool for coverage are pointed below.

1. At first from the "Network properties" tab, the p2p antennas are assigned with a name Point to Point antenna-30 meter.
2. Then antenna type is selected to the Antenna p2p.ant.
3. After that for the system parameter we create a direct link between the two points with the following parameters of minimum frequency of 5300 MHz and maximum frequency of 5500 MHz.
4. Moreover from the "map properties", the latitude and longitude of our country is set. Then clicking the extract button will automatically download the map and is needed to be saved for further use of the map. We set the maximum and minimum frequencies according to WRAN 802.22 frequency band specifications.
5. After that we determined the values of the transmit power and the antenna gain in our simulation of P2P we can have co channel gain at 20 dBi and transmitting power at 43 dBm. We also set maximum tower height to 30 meters above the ground for all antennas.
6. Then from "Unit properties" box, we have to select a P2P antenna and have to select "Place at cursor position". It will automatically send the antenna to the position.

The P2P configuration chart is shown below with some incorporated images of P2P.

Point A	Height (m)	Point B	Height (m)	Worst Fresnel	Distance (km)
P2P25	30	P2P24	30	1.9	10.49
P2P24	30	P2P23	30	1.8	8.7
P2P23	30	P2P22	30	2.4	9.7
P2P22	30	P2P26	30	1.9	9.97
P2P21	30	P2P20	30	2.1	14.98
P2P20	30	P2P19	30	2.5	11.42
P2P20	30	P2P36	30	1.7	17.34
P2P36	30	P2P35	30	1.7	16.65
P2P35	30	P2P34	30	1.9	13.17
P2P34	30	P2P33	30	1.8	13.14
P2P33	30	P2P32	30	1.8	15.26
P2P32	30	P2P48	30	1.9	17.69
P2P34	30	P2P37	30	1.7	14.35
P2P37	30	P2P40	30	2.0	11.63
P2P40	30	P2P43	30	1.7	13.34
P2P33	30	P2P44	30	1.8	18.27
P2P33	30	P2P47	30	1.8	14.08
P2P47	30	P2P42	30	1.7	15.61
P2P42	30	P2P39	30	1.6	17.25
P2P39	30	P2P41	30	1.8	18.42
P2P39	30	P2P38	30	1.8	15.62
P2P38	30	P2P30	30	1.8	18.38
P2P41	30	P2P18	30	2.1	15.16
P2P14	30	P2P45	30	1.8	13.29
P2P26	30	P3P28	30	2.2	11.40
P2P19	30	P2P18	30	1.5	21.70
P2P18	30	P2P17	30	2.5	14.43
P2P17	30	DHAKA	30	2.3	17.66

Point A	Height (m)	Point B	Height (m)	Worst Fresnel	Distance (km)
DHAKA	30	P2P14	30	1.9	16.87
P2P14	30	P2P13	30	1.9	19.27
P2P13	30	P2P29	30	1.8	15.96
P2P29	30	P2P12	30	2.0	12.47
P2P12	30	P2P15	30	1.8	18.28
P2P15	30	P2P2	30	2.1	33.29
P2P2	30	P2P1	30	3.6	29.79
P2P1	30	P2P16	30	1.6	41.13
P2P16	30	P2P3	30	2.1	43.59
P2P12	30	P2P10	30	1.8	20.54
P2P10	30	P2P11	30	1.7	14.59
P2P11	30	P2P9	30	2.0	25.28
P2P9	30	P2P8	30	1.8	42.22
P2P8	30	P2P7	30	3.4	47.98
P2P7	30	P2P4	30	11.9	50.79

Table 04: P2P Network Configuration Chart

→ Chittagong Zone

→ Sylhet Zone

→ Mymensingh Zone

→ Dhaka Zone

After doing the simulation for P2P, we see from above chart and P2P map, 4 major cites (Dhaka, Chittagong, Mymensingh and Sylhet) and 50% of the area of Bangladesh is covered. We can install at most 50 point to point antennas of 30 meters height. If transmission power is set to 43dBm, we see that in the plane or flat areas we have to set up antennas after 13.00 km on an average & average worst Fresnel is 1.9F1. But in the hilly areas we can set up the antennas at a distance of 42 .00 km on an average. The highest covered distance is 50.79 km with worst Fresnel is 11.9F1 between P2P7 and P2P4 and the lowest covered distance is 8.7 km with Worst Fresnel is 1.7F1 between P2P23 and P2P24.

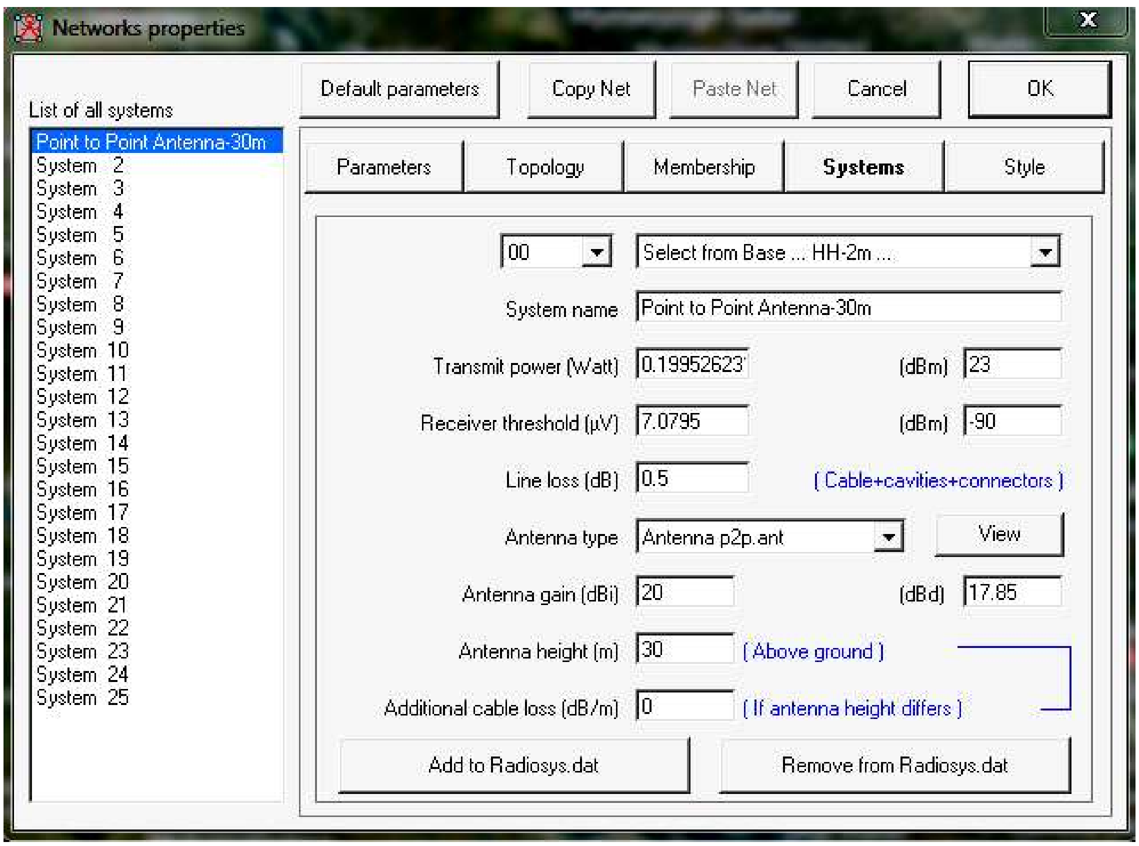

Figure 15: Systems Configuration Screenshot

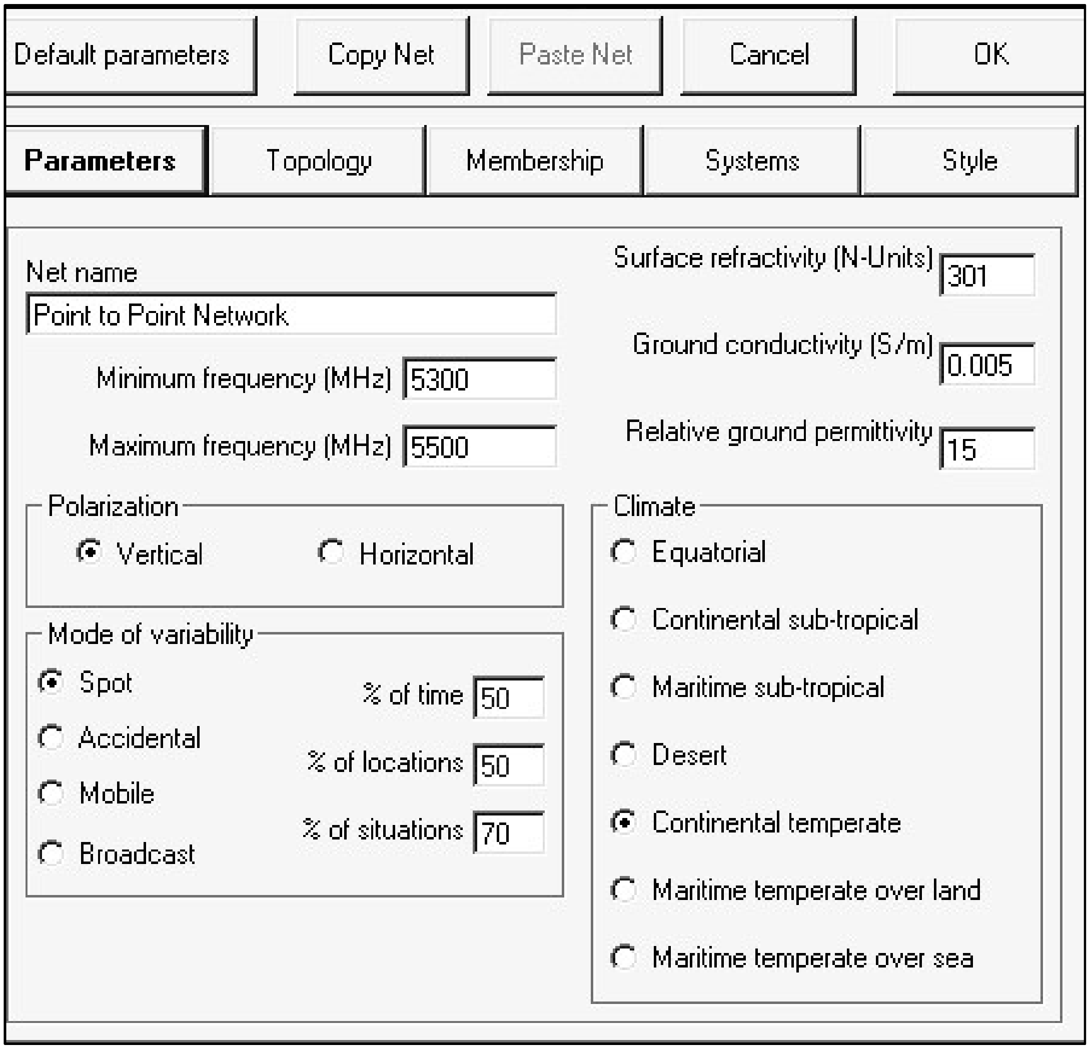

Figure 16: Network Parameters

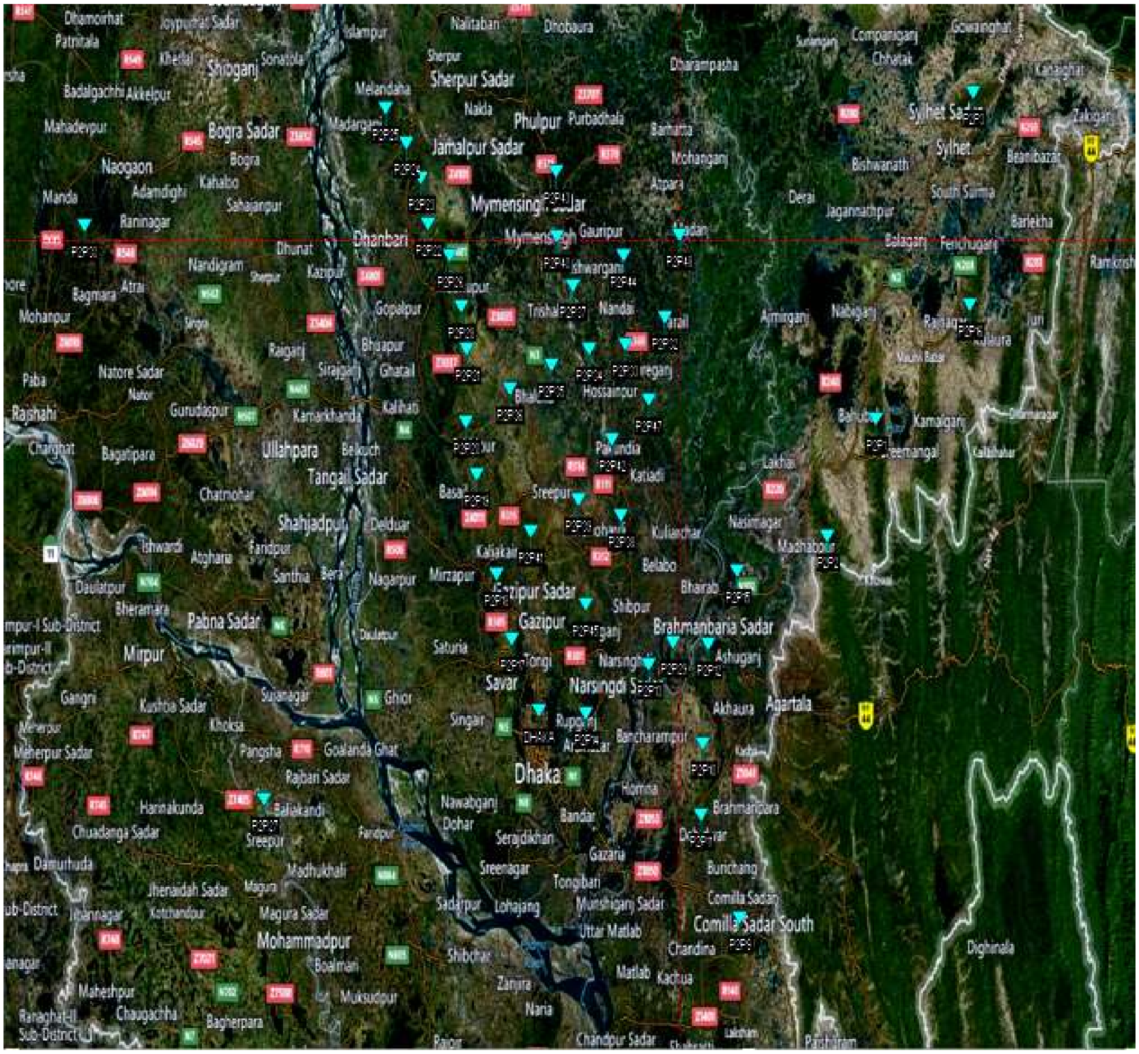

Figure 17: Point to point network map

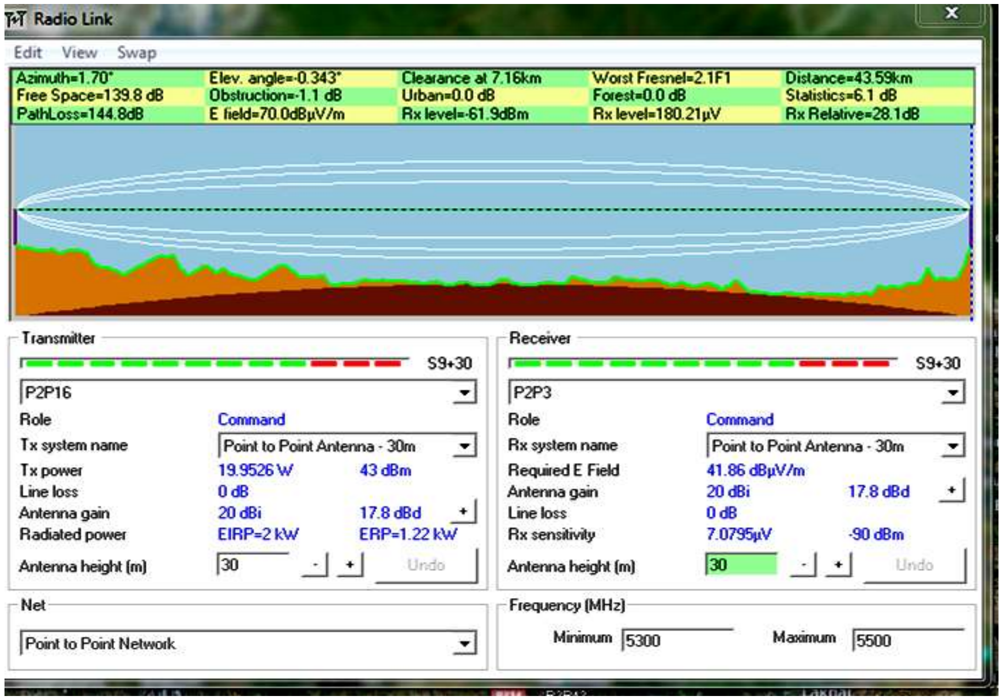

Figure 18: P2P sample screenshot

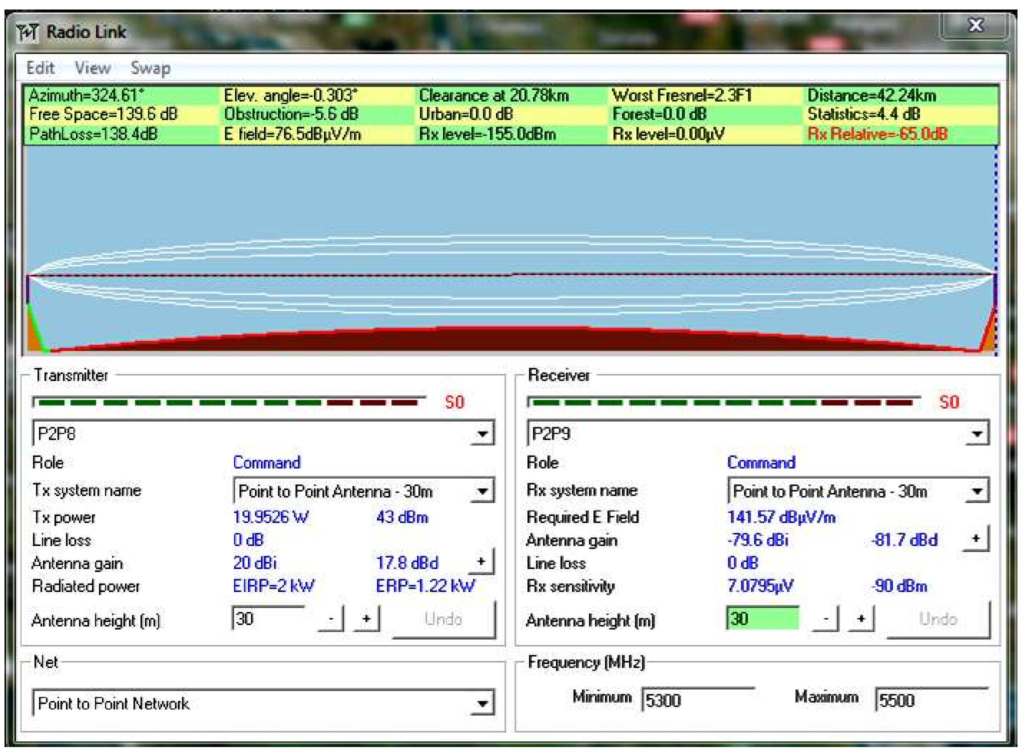

Figure 19: P2P sample screenshot

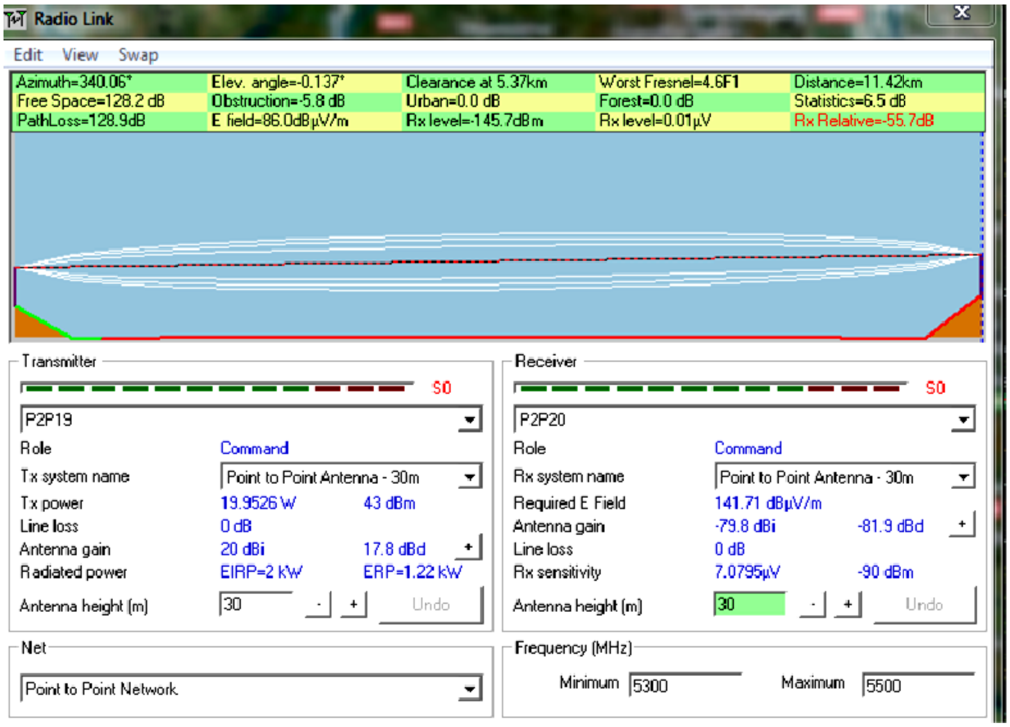

Figure 20: P2P sample screenshot

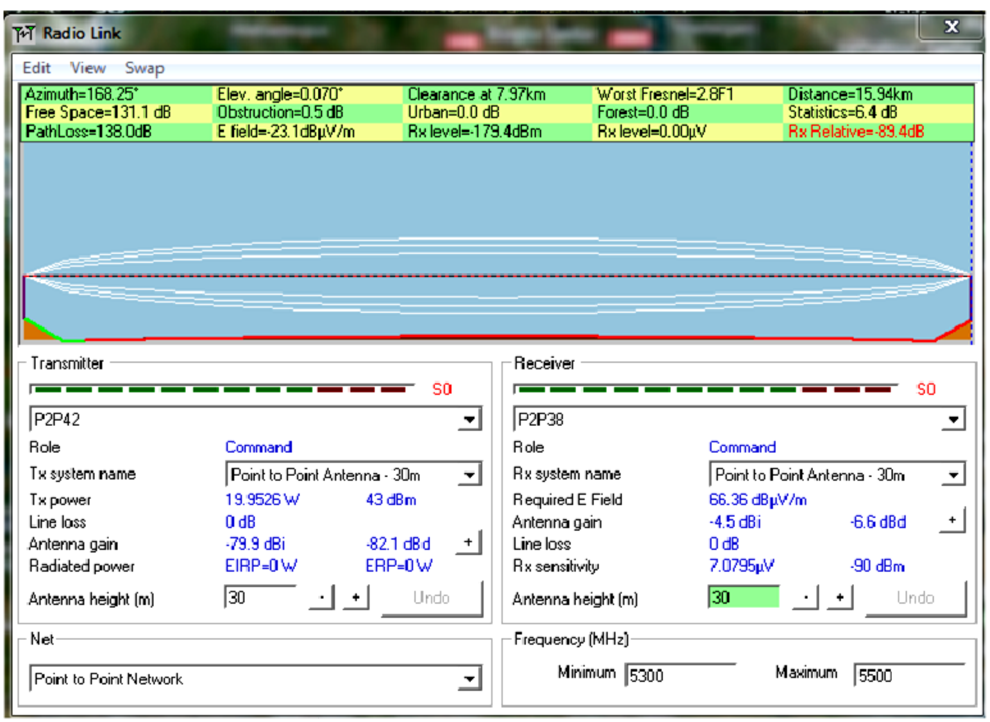

Figure 21: P2P sample screenshot

Figure 22: Discourse on the P2P joins foundation

In the guide underneath, the red imprint region is the range we wanted to cover. We thought that we took after while actualizing P2P furthermore scope system can be composed systematically as takes after we are going to envision half of the nation absolute territory as the way the guide underneath appears. The explanation for separating the guide along these lines is quite reasonable. We need to incorporate Dhaka as the focal point of the nation and Chittagong as the south-eastern corner. At the point when our connections achieve Dhaka beginning from Chittagong we wanted to move our connection straight north and north east to cover two most imperative urban communities Sylhet and Mymensingh. In any case, from Dhaka we later partitioned our connection toward Mymensingh toward the west to cover the more critical urban communities around Mymensingh like Sherpur, Jamalpur to be covered. The P2P radio wires must be set near effectively because of compelling evenness of the area and huge correspondence aggravation because of the earth ebb and flow.

For the pretense of P2P, we need much more antennas almost 50 antennas to cover up the half of our country. The main reason is that our country is consisting of plane land and for good coverage, plane land is a must which we have and the entire infrastructure Stations of the Cross has to be connected with wire from a backrest catch. But for P2P connation, it is better to have hilly region because if the Fresnel zone touches the solid ground as we see the simulation the data is corrupted or data can be tempered easily. So, if we give P2P connection to the hilly expanse of our commonwealth like Chittagong and Sylhet, then we can easily give connection to the remote control areas .So to conclude point to point networking is best for hilly reasons and much more effective than plan surfaces if consider there cover distance.

XIII. Implementation Challenges

The on location execution of the above task won't be simple however will clearly have various difficulties. The difficulties could be gathered into two classes, which are economic and technical difficulties. The economic difficulties will include: to begin with convincing administration suppliers to put resources into this new innovation (CR system) and specially to put resources into a low profit market and also attempting to realize an outlook change inside the rustic group. At the end of the day, persuading the provincial business sector to grasp this new innovation instead of adhere to the more customary methods for simply sitting in front of the TV programs, listening to radio communicate projects and utilize the phone for voice interchanges. However the more youthful era may be simpler to persuade as they are more presented to new and up and coming advances. The specialized difficulties incorporate leading constant reproductions in light of the above configuration that fuses nearby testing and recognizable proof of physical and natural prerequisites, scope and blackout criteria and so on. Because of the effortlessness of the proposed CR structure furthermore in light of the fact that those full subjective radios are nonexistent right now. This strategy however not new to the correspondences business would have required the recalculation of the commitment of WRAN base station impedance on the TV sponsor station and the related TV supporter station insurance form, subsequent to the TV promoter force would be not exactly the first TV transmitter power in Bangladesh. Field estimations as a rule force hardware mistakes onto the mimicked comes about subsequently it will be hard to precisely figure out if a channel is involved. Reception apparatus stature at both base station and client premises would likewise represent another sensible test - the count of which will rely on upon the encompassing geography. Typically radio wires for the gathering of TV channels are extremely tall and henceforth are inclined to lighting strikes; Zimbabwe being in the tropical district encounters incessant thunder and lightning exercises. Along these lines the rate of blackouts may get to be troubling. The issue of the shrouded terminal will clearly assume an imperative part in this technique. The most critical test would be the count and relief of obstruction contributed by far off TV channels, other WRAN systems, small scale cell systems and so forth. The resultant impedance exuding from the covering hubs is a noteworthy reason for concern and is typically alluded to as the conjunction issue.

XIV. Conclusion & Future Works

Based on the foregoing discussions, the aims of the project, literature reviews on cognitive radio (including WRAN) and the fact that TV bands are largely underutilized, we have proposed a contribute towards WRAN of IEEE 802.22 and it shows very promising candidate technology for providing broadband wireless access to rural Areas in Bangladesh. The problem of Bangladesh was expounded and possible solutions of bringing broadband internet connectivity to the rural community sought by examining trends in other countries with similar problems and reviewing new technologies such as cognitive radio. It was therefore shown that WRAN can utilize opportunistically TV broadcast bands and exhibiting large coverage range and favorable per cell capacity was identified as a suitable broadband access for these sparsely populated areas that are difficult to economically service by either means of wireless or wired. The simulation has been performed by using MATLAB software, which is the most suitable tool in engineering field, especially in the field of wireless communication. The cognitive radio network which is a latest and interested field, has been adopted and some parameters have been tested in this project and it was successfully carried out on VHF TV bands shows a good finding. The simulation revealed that it was possible to harness idle TV channels/frequency bands using cognitive radio technology. Implementation challenges which included both technical and economy were noted and enunciated. Major challenges highlighted in this project still require further investigations include: the effect that the antenna height has on the hidden terminal problem, the calculation and mitigation of interference contribution from distant television stations and WRAN networks in the vicinity and other primary stations and users that coexist with the problem.

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