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System Consideration, Design and Implementation of Point-To-Point Microwave Link for Internet Access

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ABSTRACT

Microwave technology is extremely used for point-to-point communications because it is more easily focused into narrower beams than radio waves, allowing frequency use, it is available higher data transmission rates and antenna sizes are smaller than at lower frequencies. The main aim of this system is to provide internet access for rural area using ePMP Force 180 5GHz subscriber module. The two sites are 1.45 km away from each other. GPS is used to determine the latitude and longitude of two sites location. Google Earth Pro software is used to check for line-of-sight in choosing potential terminal site locations. In this system, system consideration, design and analysis of line-of-sight microwave link and hardware implementations are to be carried out. In the analysis, path profile, Fresnel zone, link budget and other parameters are implemented using the link planner software.

KEYWORDS: *Microwave, ePMP Force, path profile, Fresnel zone, link budget*

1. INTRODUCTION

Microwave is a line-of-sight wireless communication technology that uses high frequency beams of radio waves to provide high speed wireless connections that can send receive voice, video, and data information. Microwave technology has been used for communication purposes since the 1940's. A microwave link is a communications system that uses a beam of radio waves in the microwave frequency range to transmit information between two fixed locations on the earth. Microwave links range from 2.4GHz to 42GHz spectrum. The higher is the frequency, the higher the available capacity but at the same time, the effective range is lowered and the link would be more susceptible to rain or high humidity.

To use a frequency, a license should usually be obtained from the legal authorities of the country. There are also a few frequency bands that are "license-free" – mainly 2.4GHz, 5GHz and 24GHz.

One of the reasons of microwave links are so adaptable is that they are broadband. They can move large amounts of information at high speeds. Another important quality of microwave links is that they require no equipment or facilities between the two terminal points, so installing a microwave link is often faster and less costly than a cable connection. Finally, they can be used almost anywhere, as long as the distance to be spanned is within the operating range of the equipment and there is clear path (that is, no solid obstacles) between the locations. Microwaves are also able to penetrate rain, fog, and snow, which mean bad weather doesn't disrupt transmission.

Microwave radio transmission is commonly used in point-to-point communication systems on the surface of the Earth, in satellite communications, and in deep space radio communications. Other parts of the microwave radio band are used for radars, radio navigation systems, sensor systems, and radio astronomy. (Mohamed Maher Hanafi, 2016)

2. PROPOSED SYSTEM

2.1 Block diagram

The block diagram of design and implementation of point-to-point microwave link for internet access is shown in figure. In this system, the signal from TP link router transfers to the transmitter module by using RJ 45 Ethernet cable. Cambium ePMP Force 180 5GHz is used as transmitter and receiver module. The signal is transmitted from transmitter module using microwave. The signals are received by Subscriber Module with Ethernet cable network.

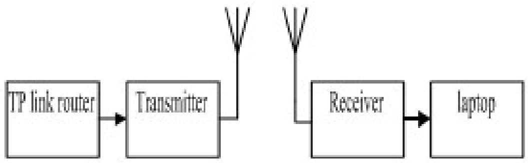

Fig1. Block Diagram of Point to Point Microwave Link for Internet Access

2.1.1 Design Considerations

A. Site selection

Site selection is the process of choosing the optimal location for an anticipated use. Since microwave communication is a line-of-sight communication, the location of the transmitter and receiver sites is verifying that there are no natural and man-made obstructions between them. For site selection, Google Earth Pro software is used to check for line-of-sight in choosing potential terminal site locations. Google Earth

Pro is a virtual globe, map and geographical information program that map the Earth by the superimposition of images obtained from satellite imagery, aerial photography and geographic information system 3D globe.

In this design, the receiver site is Taung Kwe Pagada, Loikaw (19.66750N, 097.20800E). After choosing the receiver site, the potential transmitter site is selected that are 1.45 km away from the receiver site. The transmitter is in EC department, TU loikaw (19.65450N, 097.20850E).

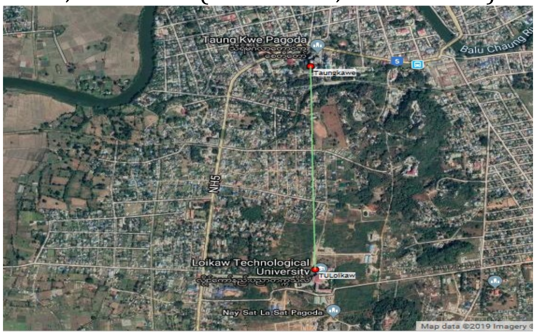

Fig2. Sites considerations using Google Earth Pro

B. Calculation of Antennas' Heights

From above table, the AP site's elevation high (e_1), peak obstruction height (e_0), and the SM site's elevation high (e_2) are 934.8, 911 and 902.9 meters above sea level respectively. d_1=0.95km, d_2=0.39km, k=4/3, F=5.8GHz, TG=10meters.

Earth curvature, $E_b = \frac{d_1.d_2}{12.75k} = \frac{0.95\times0.39}{12.75\times^4/_3} = 0.022km$

First Fresnel zone, $F_1 = 17.3\sqrt{\frac{d_1.d_2}{(d_1+d_2)F(GHz)}} = 3.76m$

60% clearance of first Fresnel zone, $F_1{}' = 0.6\times3.76m = 2.256m$

$$H_0 = E_b + TG + e_0 = 921.02m$$

Assume both AP site's antenna height and SM site's antenna height are the same, a=a_1+a_2.

$$F_1{}' = [d_1(\frac{e_2-e_1}{D})] - H_0 + a + e_1$$

The antenna height, a_1=a_2=11m.

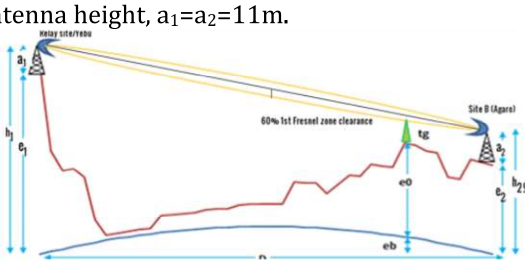

Fig3.Consideration in antenna heights and beam width

C. Antenna down tilt calculation

The Antenna Down tilt and Coverage Calculator (aka Antenna Tilt Angle Calculator) is used to determine the approximate downward angle, measured in degrees, which the transmitting antenna is to be positioned for optimal signal strength and coverage.

$$\theta = \tan^{-1}\frac{h_1-h_2}{D} = 1.39°$$

D. Fresnel Zone Clearance

The most common use of Fresnel zone information on a profile plot is to check for obstructions that penetrate the zone. Even though the path has clear line of sight, if obstructions (such as terrain, vegetation, buildings, etc.) penetrate the Fresnel zone, there will be signal attenuation. The Fresnel zone is computed along the path, usually for the distance of each of the terrain points, so the resolution of the computed and plotted Fresnel zone is comparable to the terrain data. The Nth Fresnel zone formula is a function of the wavelength (λ) and the distance along the path from each endpoint (D1 and D2): To maximize receiver strength, one needs to minimize the effect of obstruction loss by removing obstacles from the radio frequency line of sight (RF LOS). The strongest signals are on the direct line between transmitter and receiver and always lie in the first Fresnel zone.

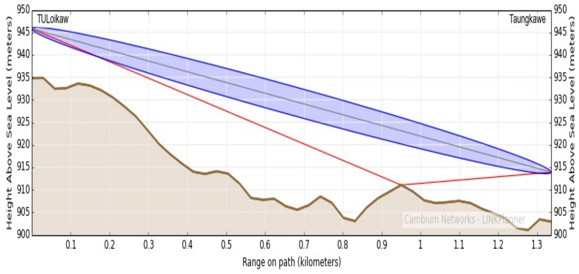

Fig4. Fresnel zone results from Link planner

E. LINK BUDGET CALCULATION

The link budget is a calculation involving the gain and loss factors associated with the antennas, transmitters, transmission lines and propagation environment.

Transmitter Power=30dBm

Antenna Gain = 16dBi

Branching loss

Branching loss (LbR =2 dB)

Radom loss

Radom loss (LrR=0.5dB

Miscellaneous losses

Miscellaneous Loss (Lmisc=2dB)

And Predicted received power, P_{RX}

$P_{RX} = R_{TX} + G_{TX} - L_{TX} - F_{SL} + G_{RX} - L_{RX}$

Where P_{RX} is received signal power (dBm), P_{TX} is the transmitter power (dBm), G_{TX} is the transmitter antenna gain (dBi), L_{TX} is the transmitter losses (dB), F_{SL} is the free space loss (dB), G_{RX} is the receiver antenna gain (dBi), L_{RX} is the receiver losses (dB).

Free space path loss

$$FSPL = 92.4 + 20\log f\,(GHz) + 20\log D\,(km)$$
$$= 92.4 + 20\log 5.8 + 20\log 1.335 = 110.27dB$$

3. IMPLEMENTATION

In this part, figure (5) shows the configuration of TP-Link's LAN and DHCP setting.

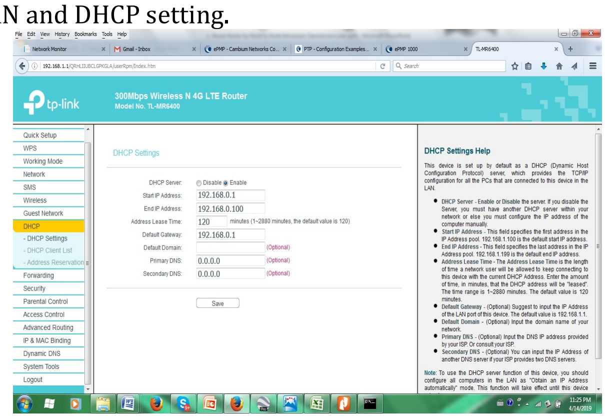

Fig5. Configuration of TP Link Setting

And, it needs to configure the settings of ePMP force180 AP's module.

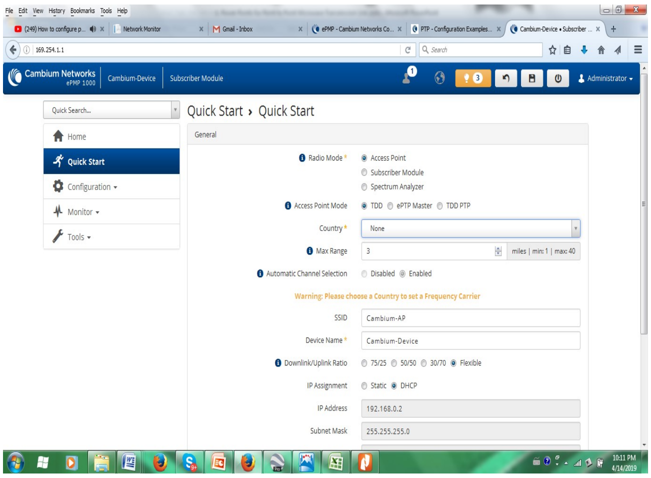

Fig6. Settings of ePMP force 180 AP's Module

Figure (7) shows the settings of SM module.

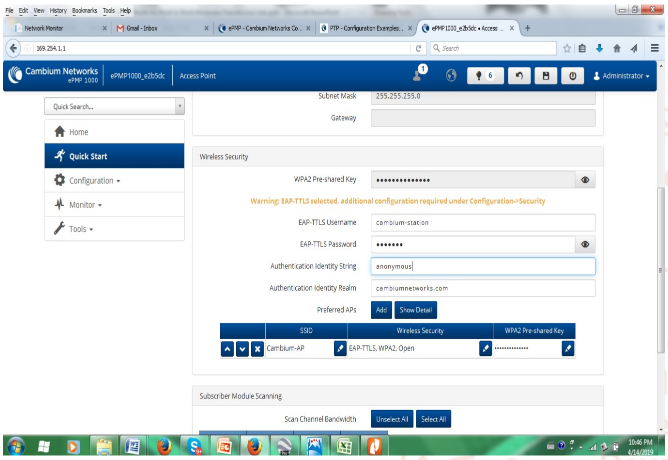

Fig7. Configurations of SM Module

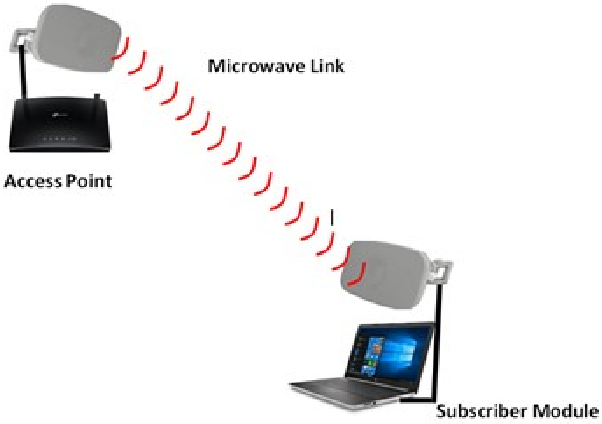

Fig8. Project Configuration

3.1 Analysis and Results

Transmission requirements:

Maximum data rates > 155 Mbps

Minimum required availability: 99.999%

Ray parameters:

5.8GHz

Modulation =Adaptive; BW=40MHz; TX power=26 dBm.

In this part, table (1) shows the different parameters of obstacles, terrain heights and results of Fresnel zones and antenna heights

Obstacle	Distance from Tx.d1 (km)	Distance from Rx.d2 (km)	Terrain height (m)	Earth Curvature (m)	Tree Growth (m)	first fresnel clearan-ce F1 (m)	Total Extended high (m)
1	0	1.33547	934.8	0	10	0	944.80000
2	0.02896	1.30651	934.9	0.00223	10	1.20916	946.11139
3	0.05953	1.27594	932.4	0.00447	10	1.71320	944.11767
4	0.08850	1.24698	932.6	0.00649	10	2.06492	944.67141
5	0.11907	1.21640	933.6	0.00852	10	2.36564	945.97416
6	0.14803	1.18744	933.2	0.01034	10	2.60611	945.81645
7	0.17860	1.15687	932.1	0.01215	10	2.82551	944.93766
8	0.20756	1.12791	930.6	0.01377	10	3.00763	943.62140
9	0.23813	1.09734	928.6	0.01537	10	3.17756	941.79293
10	0.26709	1.06838	926.3	0.01679	10	3.32054	939.63733
11	0.29767	1.03781	923.3	0.01817	10	3.45491	936.77308
12	0.32663	1.00884	920.2	0.01938	10	3.56823	933.78761
13	0.35559	0.97988	917.9	0.02050	10	3.66924	931.58973
14	0.38616	0.94931	915.8	0.02156	10	3.76359	929.58516
15	0.41512	0.92035	914	0.02247	10	3.84219	927.86466
16	0.44569	0.88978	913.5	0.02333	10	3.91448	927.43780
17	0.47466	0.86082	914.1	0.02403	10	3.97337	928.09740
18	0.50523	0.83024	913.6	0.02467	10	4.02588	927.65055
19	0.53419	0.80128	911.3	0.02518	10	4.06682	925.39200
20	0.56476	0.77071	908.1	0.02560	10	4.10102	922.22663
21	0.59372	0.74175	907.7	0.02591	10	4.12510	921.85101
22	0.62429	0.71118	907.9	0.02612	10	4.14189	922.06800
23	0.65325	0.68222	906.3	0.02622	10	4.14970	920.47592
24	0.68222	0.65325	905.5	0.02622	10	4.14970	919.67592
25	0.71279	0.62268	906.5	0.02611	10	4.14122	920.66733

26	0.74175	0.59372	908.5	0.02591	10	4.12510	922.65101
27	0.77232	0.56315	907	0.02558	10	4.09945	921.12504
28	0.80128	0.53419	903.7	0.02518	10	4.06682	917.79200
29	0.83185	0.50362	903	0.02464	10	4.02336	917.04800
30	0.86082	0.47466	906	0.02403	10	3.97337	919.99740
31	0.89139	0.44408	908.1	0.02329	10	3.91093	922.03422
32	0.92035	0.41512	909.5	0.02247	10	3.84219	923.36466
33	0.94931	0.38616	911	0.02156	10	3.76359	924.78516
34	0.97988	0.35559	909.6	0.02050	10	3.66924	923.28973
35	1.00884	0.32663	907.6	0.01938	10	3.56823	921.18761
36	1.03941	0.29606	907	0.01810	10	3.44823	920.46633
37	1.06838	0.26709	907.2	0.01679	10	3.32054	920.53733
38	1.09895	0.23652	907.5	0.01529	10	3.16913	920.68442
39	1.12791	0.20756	907	0.01377	10	3.00763	920.02140
40	1.15848	0.17699	905.7	0.01206	10	2.81471	918.52677
41	1.18744	0.14803	904.8	0.01034	10	2.60611	917.41645
42	1.21801	0.11746	903.6	0.00842	10	2.35115	915.95957
43	1.24698	0.08849	901.5	0.00649	10	2.06492	913.57141
44	1.27594	0.05953	901	0.00447	10	1.71320	912.71767
45	1.30651	0.02896	903.4	0.00223	10	1.20916	914.61139
46	1.33547	0	902.9	0	10	0	912.90000

Table1. Path Profile

4. CONCLUSIONS

Point to point microwave links are widely used as a cost effective alternative to fiber optic cabling for interconnecting the network of two sites with distances of few hundred meters and up to 50 km or more. In this system, the distance between two points is 1.45 km longs and two antennas must be line of sight. In microwave communication, higher frequency bands are used in shorter hops and lower frequency bands are used in longer hops. The lower frequency band is not used in urban areas. The link planner software is developed to help telecommunications engineers to design and simulate a new microwave line-of-sight radio link over varieties of terrain and paths without going into detailed mathematical equations. This system is simulated with Cambium link planner software to achieve link availability of 99.999%. However, design and implementation of a successful and reliable point to point microwave link requires good theoretical knowledge about RF design and antennas, as well as good deal of practical experience.

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