Propagation Study during rain for reliable Communication Services at Gangtok

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Abstract: The 4G system is expected to provide a content rich and secure all-IP based mobile broadband services to laptop or computer wireless modems, smart phones, and other mobile devices. Facilities such as ultra-broadband Internet access, IP telephony, gaming services, and streamed multimedia is given to users. The present research work is to improve the quality of 4G services at Gangtok, a heavy raining zone under sub-tropical hilly Indian region by identifying the communication problems that will provide a reliable and cost effective solutions in future for uninterrupted communication. The present paper discusses the rainfall and rain attenuation in this particular place and comparative studies with various other interrelated parameters.

Index Terms: Elevation angle, Rainfall rate, Rain attenuation, Conversion method.

I. INTRODUCTION

The term 4G**,** the fourth generation of broadband cellular network technology succeeding 3G is used broadly to include several types of broadband wireless access communication systems in addition to cellular telephone systems. The specific word to describe 4G is MAGIC—Mobile multimedia, Anytime anywhere, Global mobility support, Integrated wireless solution, and Customized personal service. India's mobile market has seen a significant rise in the last few years. A key part of that vision is 4G connectivity, which has been rolling out since 2012. One of the key stories in the country's digital transformation in 2016 was the launch of 4G by Reliance Jio. When compared to 3G, 4G offers greater bandwidth at a lower latency, with downloads speed of 45Mbps [1]. However, receiving that kind of speeds is entirely lies on network connectivity and congestion, which was a major issue during the 3G rollout. Gangtok, a North East part of India hill forest region where the average rainfall is higher than other parts of India is still digitally deprived due to climatic disturbances in monsoon season. This paper focuses on the signal impairment due to rain over Gangtok for more that 10 GHz frequency as it is a requirement for future days communication technology.

From the rainfall data of three decades (1983-2016), the mean weekly, monthly and yearly rainy days have been estimated[2] .It is considered as rainy when it received rainfall ≥2.5 mm. This definition of rainy day is required as Gangtok is within the orographic rain area. At Gangtok all the months have received rainfall however the highest numbers of rainy days are found during July to September. The rainfall data have showed that in the past three decades, the number of rainy days have increased at the rate of 8.7 days/decade from 1981-90 (decade mean=153.5 days/year) to 1990-2000 (decade mean=162.2 days) but decreased at the rate of 7.2 days/decade for the period from 1991-2000 to 2001-10 (decade mean=155 days)[1]. The Indian Meteorological Department (IMD) rainfall data for 33 years has been collected and used in the evaluation of rain attenuation to setup a new mobile network or a wireless network [3, 4, 5].

Prior to 4G, when the 3G technology is launched in India by BSNL, a government undertaking Telecommunication Company, it gave high speed mobile broadband, video calling service, mobile TV etc. Mobile broadband provides wireless internet , which enables to access internet anywhere any time. The 3G and 4G provides additional feature like video calls, live TV broadcasting, high speed internet, emails and easy downloading other than any other old services like 2G network. Now the main constraint of the 3G technology as well as 4G, is the high speed communication. The high speed communication needs error-free reliable data communication [6]. North East (NE) India is a heavy rain area which is covered with tropical forests. There are eight states in the region. The average rainfall is higher than other parts of India. That's why it is very important to design proper telecommunication services as this part of India suffered much signal degradation due to rain .Gangtok is one of them.

II. DATA AND METHODOLOGY

The measured rain rate at 0.01% of time exceedance is 50mm/hr [7] which is slightly higher than the ITU-R P.837-1[8].As per figure 1, it is clearly visible. Noth East(NE) part of India like Gangtok comes under K region mentioned [9] as per ITU-R which provides rain rate 42mm/hr at 0.01% of time exceedance.

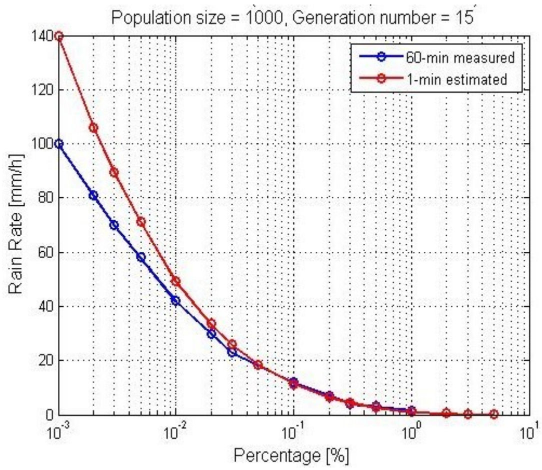

Fig. 1. Rain rate with percentage of time exceedence.

As per figure 2, ITU-R predicted rain attenuation underestimates the measured rain attenuation for Gangtok. As from the last two decades the rainy days are dropping down, the maximum annual average rain rate has been considered to locate the worst condition.

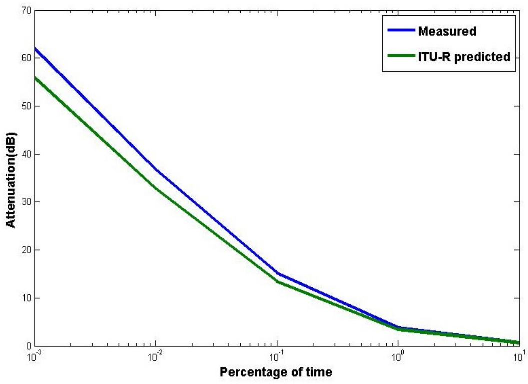

Fig. 2. Attenuation in dB with respect to percentage of time (%)

Other important parameters for predicting rain attenuation are also observed here and their effects are investigated too. As per figure 3 for Gangtok (27.20^0 N, 88.40^0 E and 3637 metre from sea level)as per Table 1, keeping the elevation angle fixed at 60^0, rain attenuation change with frequency has been observed and found to be proportional.

Table 1: Lat-Long of Gangtok.

PLACE	LATITUDE	LONGITUDE
Gangtok	27.200^0 N	88.400^0 E

Table 2: Calculated attenuation value(Elevation angle at 60^0 and at 40 GHz frequency)

Time exceedance (%)	Attenuation(dB)
0.001	62.0312
0.01	36.8031
0.1	15.2551
1	3.8053
10	0.7239

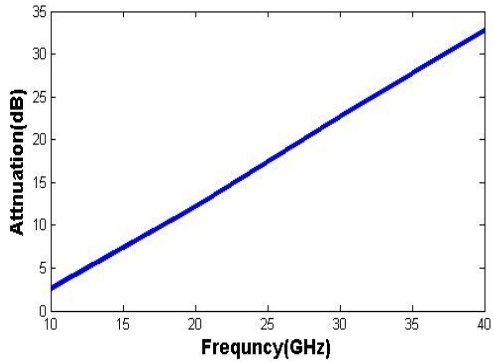

Fig. 3. Attenuation (dB) with respect to frequency for 60 degree elevation angle for Gangtok.

For installation of satellite signal receiver at this location elevation angle is a vital issue for reducing signal impairment at frequency of 10 GHz and more. Figure 4 describes the relation between attenuation and elevation angle. Attenuation proportionally decreases with increase of elevation angle. Where for different elevation angles at 40 GHz signal frequency the attenuation value at different time exceedance are plotted at figure 5 and also as Table 2. Algorithm followed as per ITU-R[10] for prediction of Attenuation are as follows:

Step 1 : Obtain the effective rain height H

Step 2 : Calculate the slant path length L

Step 3 : Calculate the horizontal projection of the Slant-path (Lg).

Step 4 : Determine the specific attenuation (dB/Km)

Step 5: Calculate the horizontal path adjustment factor $r_{h0.01}$ for 0.01% of the time

Step 6 : Calculate the adjusted rainy path length Lr (Km) through rain

Step 7 : Calculate the vertical adjustment factor $r_{v0.01}$ for 0.01% of the time.

Step 8 : Calculate the effective path length through rain Le (Km)

Step 9 : Determine the attenuation exceeded for 0.01% of an average year.

Step 10 : Determine the attenuation to be exceeded for other percentages of an average year in the range 0.001% ~ 10%.

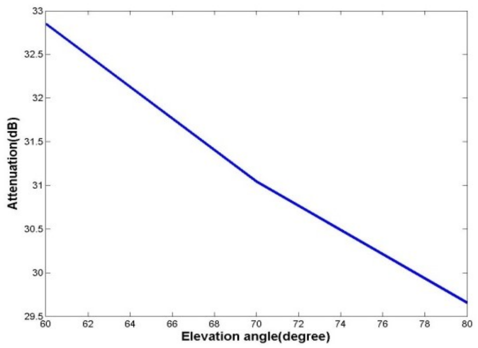

Fig. 4. Attenuation (dB) with respect to elevation angle for Gangtok where frequency is 40GHz.

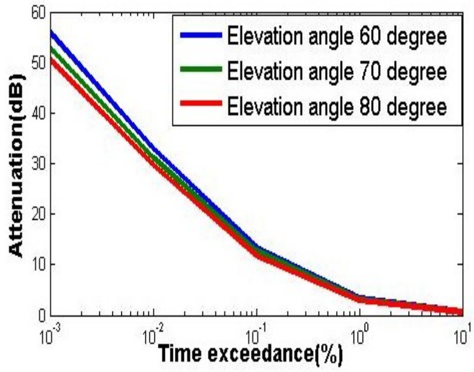

Fig. 5. Attenuation (dB) with respect to time exceedance at different elevation angles at 40 GHz.

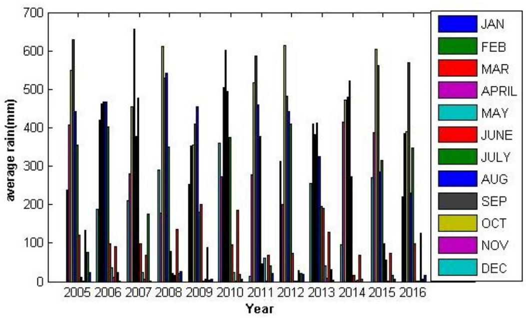

Fig. 6. Rain fall rate month wise for year(2005-2016)

From figure 6 it is clearly visible that every year May-September in Gangtok is the heavy rain reason. For the seasonal rain at high value, the attenuation is also very high at this particular period of time in this place. As the nature of figure 1 and figure 2 are same and both are plotted keeping x axis as percentage of time, the relation is established that rain rate and attenuation is proportional with each other.

III. CONVERSION METHOD

Another method for conversion of rain rate is very effective in tropical region where local monthly or yearly cumulative data are available. As IMD data provides cumulative value of rain Karasawa [11] model is found to be effective .By taking the data from 2005-2011, the $R_{0.01}$ is coming as 33.36 mm/hr as per Karasawa model of rain rate prediction which is quite lesser than ITU-R prediction. The reason is the prediction is taken with an average of 30 days where the exact value of rainy day is missing. Therefore exact prediction model needed exact number of rainy days.

IV. CONCLUSION

This paper draws the conclusion towards adequate information of rain, no of rainy days, type of rain over the location of interest which is much needed for calculation of signal impairment for reliable communication link in Gangtok. For installation of receiver, the attenuation predicted is following the relation as described by the ITU-R model with elevation angle, frequency etc However an underestimation is observed because of local rain rate which is quite different from ITU-R due to orographic nature of the rain there.

REFERENCES

[1] https://www.androidcentral.com/4g-india-everything-you-need-know.

[2] H. Rahman, R. Karuppaiyan, P. C. Senapati, S.V. Ngachan and Ashok Kumar. An analysis of past three decade weather phenomenon in the mid-hills of sikkim and strategies for mitigating possible impact of climate change on agriculture .An analysis of past three decades weather,2nd Chapter.

[3] L. J. Ippolito (1981), Radio propagation for Space Communication Systems, Proc. of IEEE, vol. 69, no. 6, 697-727.

[4] P. Das and B. S. Purkayastha (2008), Heavy rain effects over communication in hilly area and echo in voice signal transmission: A simulation, Int. Journal of Electronics, Communications, Computer Networks,vol. 2, no. 8, 478-486.

[5] R. K. Crane (1980), Prediction of attenuation by rain, IEEE 0090-6778/80/0900-1717, pp. 1718-1733.

[6] P. Das, Lingfen Sun and B. S. Purkayastha, , Propagation Study during Rain on DTH Service in North East India, Assam University Journal of Science & Technology, ISSN 0975-2773, Vol.7,137-143,2011

[7] Rajarshi sen and M P Singh. Statistics of one minute rain distribution in India. Indian Journal of Radio and Space physics.vol.28, April 1999,pp.66-69.

[8] International Telecommunication Union, Characteristics of precipitation for propagation modelling, Recommendation P.837-1, ITU-R Recommendation, 2003.

[9] Y Sulochana,P Chandrika,S.Vijaya.Rain rate and rain attenuation statistics for different homogenous regions of India. Indian Journal of

Radio and Space physics .vol.43,October 2014. 303-314.

[10] International Telecommunication Union, Propagation data and prediction methods required for the design of Earth-space telecommunication systems, Recommendation P.618-8, ITU-R Recommendation, 2003.

[11] Karasawa Y. Proceedings of International symposium on Antennas and propagation held at Japan, ID2-1,p.165, 1989.

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