A Modified Way of Evaluating Loss to Sustain the QoS in Highly Populated Area

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Abstract

From the past few years the wireless communication system technologies increasing significantly, which shows perceptible impact in the field of telecommunications to develop and improve the entire system away from the means of transmission with wires to the without wires (radio frequency) communication. That means maintenance of QoS is important in the wireless system because it is the key problem of today's wireless communication system due to unending requirements of user. Quality of Service (QoS) is the capacity to define the performance in any responsible system. Exact description of radio channel through basic parameters and using the mathematical models are important to predict the signal coverage, attainable data rate explicit performance quality of substitute signaling and reception schemes. In This paper we will discuss A Modified way of evaluating loss to sustain the QoS in highly populated area. Here we analyze the QoS in terms of received signal strength. To achieve it we have taken the field data and calculated the path loss at 900 and 1800 MHz frequency and compared graphically with existing path loss models and found a reliable model which gives the results near to the calculated field data. After observing the results we give correction factor to attain more reliability in the existing reliable model for that particular area specified.

Keywords*: Quality of Service (QoS), Fixed wireless access networks (FWANs), Path loss, Received signal strength, Key Performance Indicators (KPIs).*

1. Introduction

At present generation the most of conventional wired network systems are replaced by the wireless network systems. We know the main difference in between these two is the change from a fixed network location to mobile network location, i.e. an address is no longer a physical location and an address will reach the wireless station. The main advantage of Wireless networks is flexibility, easy installation &quick maintenance. This reason is to justify the prospective additional wireless network QoS techniques. Quality of service, the name itself explains the excellence or performance of any responsible system and it is the capacity to define the performance in any responsible system [1]. The term Quality of Service is used to assign a set of parameters which are proposed to signify Assessable aspects of the subjective "perceived quality". The criteria taken into account by the user to justify a service vary according to the nature of the considered service. In the field of wireless networks, quality of service was defined in the ITU standard X.902 as "A set of quality requirements on the collective behavior of one or more objects"[14]. It consists of all Requirements of a connection, such as service time response, frequency response, signal to noise ratio (SNR), path loss, cross-talk, interrupts, audio levels, etc. the path loss is one of the important requirement in the evaluation of QoS. Path loss plays very important role at Network planning level. Path loss (or path attenuation) is an unwanted introduction of energy tending to interfere with the proper reception and reproduction of the signals during its journey from transmitter to receiver [2]. It reduces power density (attenuation) of an electromagnetic wave as it propagates through space. Radio wave signal path loss is an important one in the analysis and design of a radio communication system. The signal path loss generally determines many parameters of the radio communications system like transmitter power, and the antennas, especially their gain, height and general location.

The path loss also affects other parameters such as necessary receiver sensitivity, the form of transmission used and many other factors. Due to this, it is essential to realize the reasons for radio path loss, and to be capable to determine the levels of the signal loss for a give radio path. The path loss is repeatedly mathematically and these calculations are repeatedly undertaken to prepare the coverage or system design activities Therefore, path loss calculations are used in many radio and wireless survey tools determine signal strength at different locations. This type of wireless survey tools are used to help determine the radio signal strengths before installing the equipment. The installation of macro cell base station is very high so before installation radio coverage surveys are important [13]. QoS is a generally used in every scenario where quality of a system is mentioned.

Fig. 1 Satellite View of the Narnaul City

The term QOS is considered as the ability to give declaration that the requirements of all applications must be satisfied. Depends on the particular type of application, QoS in fixed wireless access networks can be considered by reliability, robustness, availability, and security, among others. Some QoS parameters are used to measure the amount of satisfaction of these services, like throughput, delay, jitter, and packet loss rate [3-7]. There are many methods are there to sustain the QoS like increasing the power of the transmitter, increasing the sensitivity of the receiver, antenna height, antenna gain, location of antenna, diversity techniques [13]. The measurements are taken in highly populated area of Narnaul city, Haryana, India. The satellite view of the Narnaul City is shown in Fig. 1.

2. Loss Factor

Signal path loss can be caused by many factors. In a global environment there are many factors that affect the actual RF path loss. When planning any radio or wireless system, it is necessary to have a broad understanding the elements that give rise to the path loss, and in his way design the system accordingly. The following are some of the major elements causing signal path loss for any radio wave system [8, 11].

2.1. Free Space Loss

This loss occurs as the signal travels from transmitter to receiver through space without any other effects attenuating the signal. The energy of any signal decreases when it travels a larger distance in the space according to the conservation of energy.

2.2. Multipath

In a real global environment, signals will be reflected and they will reach the receiver via a number of different paths. These signals may add or subtract from each other depending upon the relative phases of the signals. This entire process leads to a loss which is multipath loss. Mobile receivers (e.g. Mobile phones) are subject to this effect which is known as Rayleigh fading.

2.3. Atmosphere

It affects radio signal paths. It affects at low frequencies, especially below 30-50MHz, the ionosphere has a major effect, reflecting them back to Earth. At frequencies above 50MHz and more the troposphere has a major effect on the radio path. For UHF broadcast this can extend coverage to approximately a third beyond the horizon.

Path loss plays vital role to decide the QoS for wireless communication at network planning level (NPL). Path loss causes poor signal strength at the receiver side [12]. So that the receiver is not able to detect the original signal. All wireless communication operators use Key Performance Indicators (KPIs) to judge their network performance and they evaluate the Quality of Service (QoS) regarding end user perspective. All the events being occurred over air interface are triggering different counters in the Base Station Controller (BSC). To measure path loss we have many more models. In all those models Okumara model is giving more reliable results which are near to the data taken after comparing with the practical drive test. All the path loss models are designed by calculating field data in different environments One of the most general models for signal prediction in large urban macro cells is Okumura's model [8,10]. This model is applicable frequency ranges of 150-1920 MHz and over distances of 1-100 Km. Okumura used extensive measurements of base station-to-mobile signal attenuation to develop a set of curves giving median attenuation relative to free space of signal propagation in irregular terrain. The base station heights for these measurements were 30-100 m, the upper end of which is higher than typical base stations today. The path loss formula of Okumura is given by

$$L50(dB) = Lf + Amu(f,d) - G(h_f) - G(h_r) - G_{AREA} \tag{1}$$

where d is the distance between transmitter and receiver, $L50$ is the median (50th percentile) value of propagation path loss, Lf is free space path loss, Amu is the median attenuation in addition to free space path loss across all environments, $G(ht)$ is the base station antenna height gain factor, $G(hr)$ is the mobile antenna height gain factor, and G_{AREA} is the gain due to the type of environment. The values of Amu and G_{AREA} are obtained from Okumura's empirical plots [8,10]. Okumura derived empirical formulas for $G(ht)$ and $G(hr)$ as

$$G(h_t) = 20\log_{10}\left(h_t/200\right), 30m<h_t<1000\text{m} \quad (2)$$

$$G(h_r) = 10\log_{10}\left(h_r/3\right), h_r \le 3m \quad (3)$$

$$= 20\log_{10}\left(h_r/3\right), 3m<h_r<10\text{m} \quad (4)$$

Correction factors related to terrain are also developed in [10] that improve the model accuracy. Okumura's model has a 10-14 dB empirical standard deviation between the path loss predicted by the model and the path loss associated with one of the measurements used to develop the model. Okumura's model is wholly based on measured data and doesn't provide any analytical explanation. The major disadvantage with the model is its slow response to rapid changes in the terrain; therefore the model is fairly good in urban and suburban areas, but not good in rural area.

3. Modified Path Loss Model

With the help of the above model we are not getting the exact results that mean some more effects are there which we have to consider in the mentioned environment where drive test is conducted. In this congested highly populated environment large buildings can be one of the factors which can affect the signal strength that means indirectly path loss. Because when the radio signal passes into a medium like large buildings and foliage which are not totally transparent to radio signals. This can be explained by the traveling of a light signal passing through a transparent glass. The terrain over which signals travel will have a major effect on the signal. the buildings reflect radio signals and they also absorb them. Path loss associated with diffraction down to street level depends on the shape and construction of the buildings in the vicinity of the mobile. A simple approximation to this process for receiving antennas near street level is obtained by assuming a row of buildings to act as an absorbing half-screen located at the center of the row. In this case the field amplitude at the mobile is obtained by multiplying the roof top field by the following factor [9, 10]. As we already mentioned that the path loss formula of Okumura is given by

$$L50(dB) = Lf + Amu(f,d) - G(h_f) - G(h_r) - G_{AREA} \quad (5)$$

By considering the influence of building geometry we can modify the formula as

$$L_{okumara\ new} = L50\ (dB) + A + K \quad (6)$$

Where $A = 5\log\left[\left(\frac{d_b}{2}\right)^2 + (h-h_m)^2\right] - 9\log d_b + 20\log\{\tan^{-1}\left[2(h-h_m)/d_b\right]\}$

d_b= Spacing between buildings
h= height of the building
h_m =mobile antenna height
K=log(f_c)
f_c=900MHz

The equation (6) gives the modified approach for calculation of the path loss.

4. Observations and Results

Practically measured data was taken in the urban area using spectrum analyzer at 900MHz and 1800 MHz frequency. The power from the transmitter is 43dBm. The data was taken in the highly congested area. The reference distance taken is 1km. Measurements were taken in regular intervals between 1000m and 5000m. By observing the practical received power strength we got a conclusion that The path loss from the field data is near to the okumara model as shown figure 2. The accuracy of the any existing model is going to suffer when they are used in the surroundings or the fields other than they were designed so the okumara model need some correction to get the accurate results in the particular environment mentioned above at which we have taken the field measured data. But in this model we are not getting the exact results that means some more effects are there which we have to consider in the mentioned environment where drive test is conducted. In this congested urban environment large buildings can be one of the factors which can effect the signal strength that means indirectly the path loss. After observing the all plots we got a conclusion that by considering the building effect in the existing okumara model we got exact results as shown in fig 2. Path loss is indirectly proportional to the received signal strength because as path loss increases the received signal strength decreases i.e QoS is also decreases decreases as shown in fig 3 and fig 4.

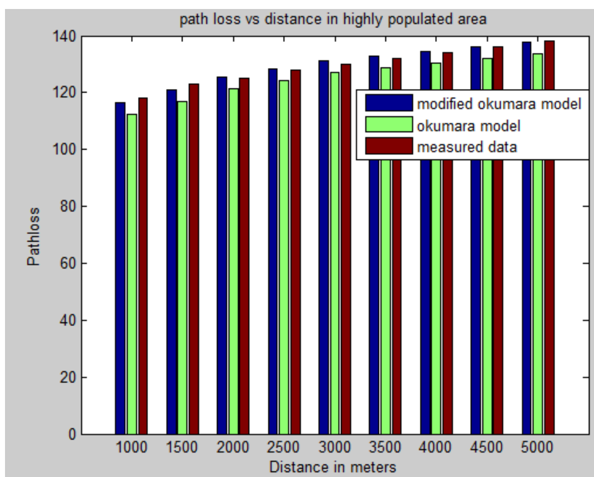

Fig. 2 Measured Path Loss, Okumara and Modified Okumara Model with Distance

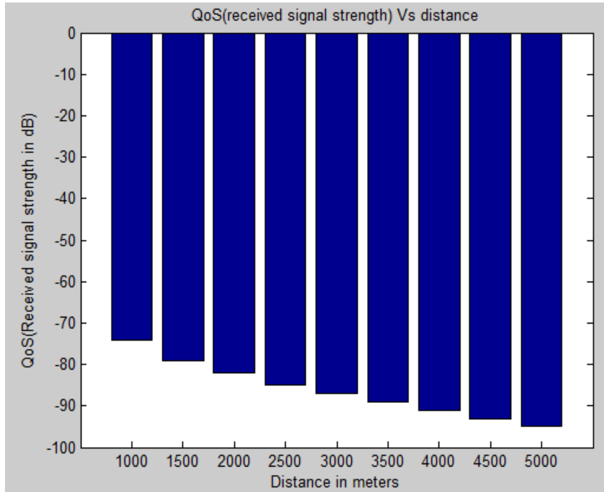

Fig.3 The Variation of the QoS in Terms of Received Signal Strength and Distance

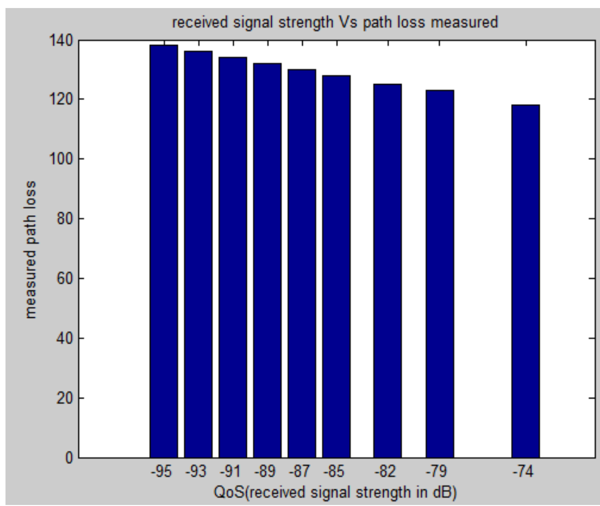

Fig.4 The Variation of QoS in Terms of Received Signal Strength with Path Loss

The error in the path loss model before and after modification with respect to path loss is shown in fig5. It is clear that the Okumara model before modification is giving more error comparing with the same model after modification.

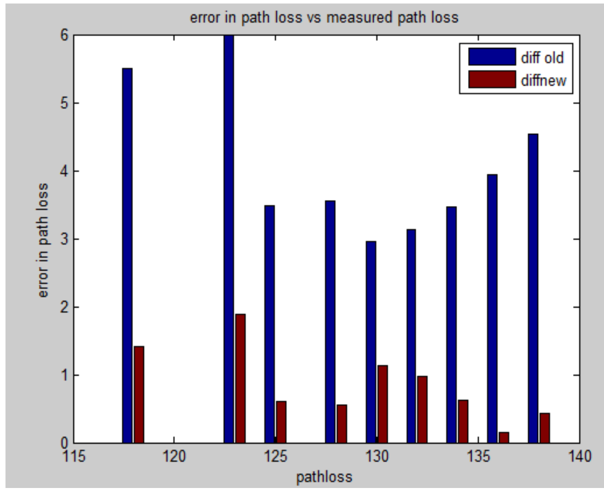

Fig.5 The Variation of Error in Path Loss with Measured Path Loss

5. Conclusion

To understand the effect of path loss on QoS we have taken the field data (Received signal strength) using spectrum analyzer. With the help of this study we analyzed that the QoS (in terms of received signal strength) decreases rapidly in highly congested area as the distance increases. In other words we can say that as the path loss is inversely proportional to QoS. From this it is cleared that if you know the path loss clearly, we can sustain the QoS. So to maintain QoS we gave a modified model in highly populated area of Narnaul city, Haryana, India. With the help of this modified model we can predict the path loss more effectively than the existing models.

References

[1] W.C. Hardy, *QoS: Measurement and Evaluation of Telecommunications Quality of Service*, John Wiley & Sons, 2001.

[2] *public domain material from the General Services Administration* document "Federal Standard 1037C" (in support of MIL-STD-188).

[3] El-Gendy, M. A.; Bose, A.; Shin, K. G. Evolution of the Internet QoS and support for soft real-time applications. *Proceedings of the IEEE* 2003, *91*(7), 1086-1104.

[4] Chen, D.; Varshney, P. K. QoS Support in Wireless Sensor Networks: A Survey. In Proc. of the Int. Conf. on Wireless Networks, Las Vegas, USA, June 2004.

[5] Li, Y.J.; Chen, C.S.; Song, Y.-Q.; Wang, Z. Real-time QoS support in wireless sensor networks: a survey. In Proc of 7th IFAC Int Conf on Fieldbuses & Networks in Industrial & Embedded Systems (FeT'07), Toulouse, France, Nov. 2007.

[6] Bouyssounouse, B. ; Sifakis, J. (eds.) Embedded Systems Design: The ARTIST Roadmap for Research and Development. Lecture Notes in Computer Science 3436, Springer-Verlag, 2005.

[7] Feng Xia, " QoS Challenges and Opportunities in Wireless Sensor/Actuator Networks'', *Sensors* 2008, *8*, 1099-1110

[8] T.S. Rappaport, *Wireless Communications - Principles and Practice*, 2nd Edition, Prentice Hall , 2001.

[9] JORAM WALFISCH and HENRY L. BERTONI, FELLOW, IEEE"A theoretical model of UHF propagation in urban environments" , IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 36, NO. 12, DECEMBER 1988.

[10] Y.okumara , E.Ohmori, T.Kawano , and K.Faukudu, "Field strength and its variability in VHF and land-mobile radio service ," Rev. Elec . Commun. Lab., vol.16, pp. 825-873 1968

[11] http://www.radio-electronics.com/info/propagation/path-loss/rf-signal-loss-tutorial.php.

[12] Dinesh Sharma, R.K. Singh " The Effect of Path Loss on QoS at NPL" International Journal of Engineering Science and Technology (IJEST)

[13] Dinesh Sharma, R .K . Singh , " A Review on QoS in GSM by Considering the Path Loss & Roadmap to its Realization" in Inventi journal in 2010.

[14] ITU-T Study Group 2, Teletraffic Engineering Handbook (350 pages, 2.7MB)(It uses abbreviation GoS instead of QoS) http://www.com.dtu.dk/teletraffic/handbook/telenook.pdf

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