International Journal of Engineering & Technology, 7 (2.3) (2018) 14-17

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research Paper

Artificial neural network based antenna sensitivity assignments for chaotic internet service provider network architecture

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Abstract

The connectivity and grade of service of an Internet Service Provider (ISP) in the Philippines is observed and analysed in this research. Traditionally, the sensitivity of the antennas for wireless access points are done manually by monitoring the signal levels onsite during the installation process. Ten subscriber locations are randomly selected as test points. The connectivity of these subscribers is observed given that their sensitivities are set manually. Finally, a proposed artificial neural network algorithm is presented to improve the availability of the internet link. The proposed algorithm incorporates the random variations of the received signal levels of the internet access points and possible degradation of signals from attenuation due to rain. Experiment results show that at least 75% increase in availability is observed using the proposed algorithm during rainy events

Keywords: *Use Neural Network, Sensitivity, wireless network, attenuation.*

1. Introduction

Internet connectivity is one important thing in our lives nowadays. Most of the time, we feel very stressed when our internet connection is unavailable or lost. Today, the internet access point delivered by the Internet Service Providers use wireless access to deliver their services.

The most common wireless internet link in the Philippines is operating in the 5GHz. Not all important aspects of this frequency are taken into consideration during the installation process of the receivers on the subscriber sides. The link availability of these kinds of systems must be carefully taken care of. Several papers [1, 2, 3, 4] focus on the analysis and test of link availabilities of wireless networks.

There are many causes for link interruption or connection loss in wireless links. Multipath fading [5, 6] generates statistical variations in the receiver front end due to reflections and refractions. Attenuation due to rain [7, 8, 9] is also one reason for disconnection of wireless link, if the sensitivity of the receiver is too high, degradation in the received signal level may not be compensated by the receiver. This is the reason why for the past decade, the prediction of the attenuation due to rain [10] was a topic of interest for some researchers.

Lastly, the attenuation of the wireless link due to dust storm [11] can also be considered another important factor in analysis of link availabilities.

2. Problem Statement

The installation processes of internet access point from local internet service providers are not properly configured. The current method of setting up the antennas that will be used for internet access is done manually by observing the statistical received signal level of the receiver at the time of installation. The choice of sensitivity for the receiving antenna is done by choosing the lowest signal seen during the monitoring process plus some “experience methods” from the site engineer. Most of the time, the manual method neglects some important factors in physics particularly the attenuation of microwave signals due to rain or water vapour. An automated solution, as replacement for the manual installation process, is needed to minimize or totally eliminate the human errors in the assignment of sensitivity of the antenna. This solution must be able to detect normal allowable link distance and supply the optimal sensitivity for the receiver which also compensates for the losses due to varying weather conditions.

3. Methodology

Fig 1 shows the proposed methodology of the system. This research presents three phases of study. Phase 1 includes the selection of subscriber locations or tests sites for the installation internet access points. The second phase will discuss the current method of installing the receiver antennas in the subscriber locations and the last phase presents the proposed algorithm for automated sensitivity assignments for the receiver antennas during installation.

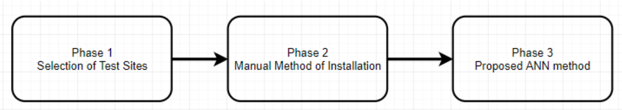

Fig. 1: Methodology of the Research

Fig. 2 shows Phase 1, the selection of potential subscriber locations randomly chosen within the territorial perimeter of the Internet Service Provider. The selected location is Cagayan de Oro City, Philippines. Smart Broadband Communications is the partner ISP for this research. Smart Broadband Communications gave the locations of their 5 ISP transmitters deployed around the province. Smart Broadband Communications also claims that their system is intended to serve short distance wireless access points that extend to a 2-km radius coverage area.

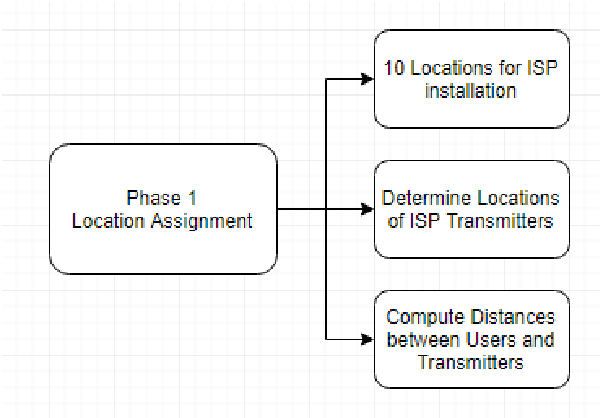

Fig. 2: Phase 1 – Location Assignment

Phase 2 of the research discusses the current method of installation of ISP receivers by first monitoring the received signal levels of the antennas and later the assignment of the sensitivity of the receiver which is done manually.

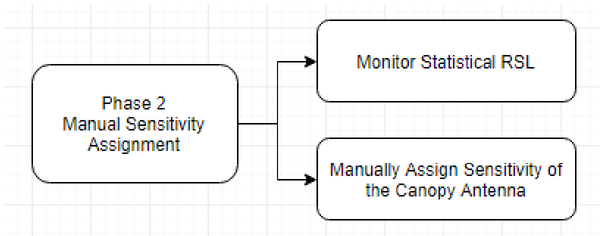

Fig. 3: Phase 2 – Manual Sensitivity Assignment

The third phase of the research is the design and implementation of an artificial neural network in computing for the optimal sensitivity needed by the wireless internet receiver. The ANN uses two input parameters, the distance of the receiver from the ISP transmitter (in km) and the ambient temperature during the time of installation (in degree Celsius). The ANN uses 20 hidden neurons and one output which is the sensitivity that will be assigned to the receiver. Fig. 4 shows the architecture of the proposed artificial neural network.

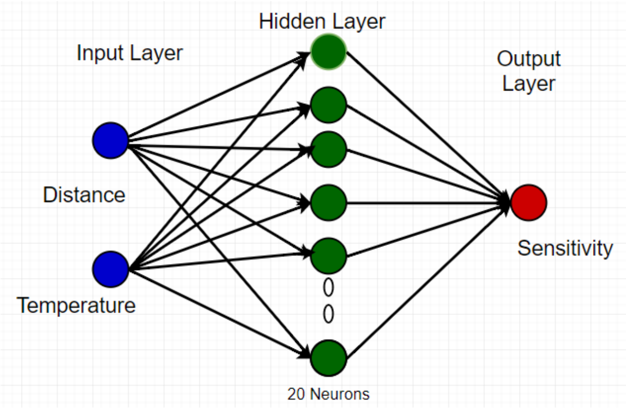

Fig 4: Artificial Neural Network Configuration

The ANN is trained, validated and tested using 720 samples. The division of the samples is shown in table 1 below. The coefficient of correlation of each task is also shown on the same table. The ANN gives at least 90% accuracy in determining the necessary sensitivity for the receiver.

Table 1: Neural Network Training, Validation and Testing Results

Tasks	Number of samples	Coefficient of correlation
Training	504	0.915
Validation	108	0.909
Testing	108	0.912

4. Discussion of results

The first part of this research is the random selection of the test sites or subscriber locations within Cagayan de Oro City, 10 locations are selected that are potential ISP subscribers. The coordinates of the 10 subscribers and the coordinates of the ISP transmitters of Smart Broadband Communications are recorded. The distance between the each subscriber to any of the 5 ISP transmitters are computed and shown in table 2 below.

Table 2: Distances of Test Sites from the Transmitters

Test Site	Distance from Transmitters (km)				
	Tx A	Tx B	Tx C	Tx D	Tx E
1	3.832	3.233	5.433	3.448	4.625
2	2.859	2.892	3.352	2.643	3.373
3	0.5414	1.599	3.826	0.9563	0.3607
4	0.4231	0.7054	4.268	0	1.306
5	4.09	4.751	0.8746	4.165	3.984
6	8.577	7.707	10.25	8.157	9.439
7	3.138	2.905	4.101	2.838	3.788
8	11.62	12.28	7.538	11.71	11.4
9	0.5170	0.7397	4.192	0.1462	1.382
10	1.058	1.648	4.768	1.358	0.9582

From the distance measurements in table 1, it can be seen that there are 5 locations that are out of range for the intended 2km radius coverage area for internet subscription. This is usually neglected by the site engineer during the installation. They normally complete the current method choosing the lowest received signal monitored during installation.

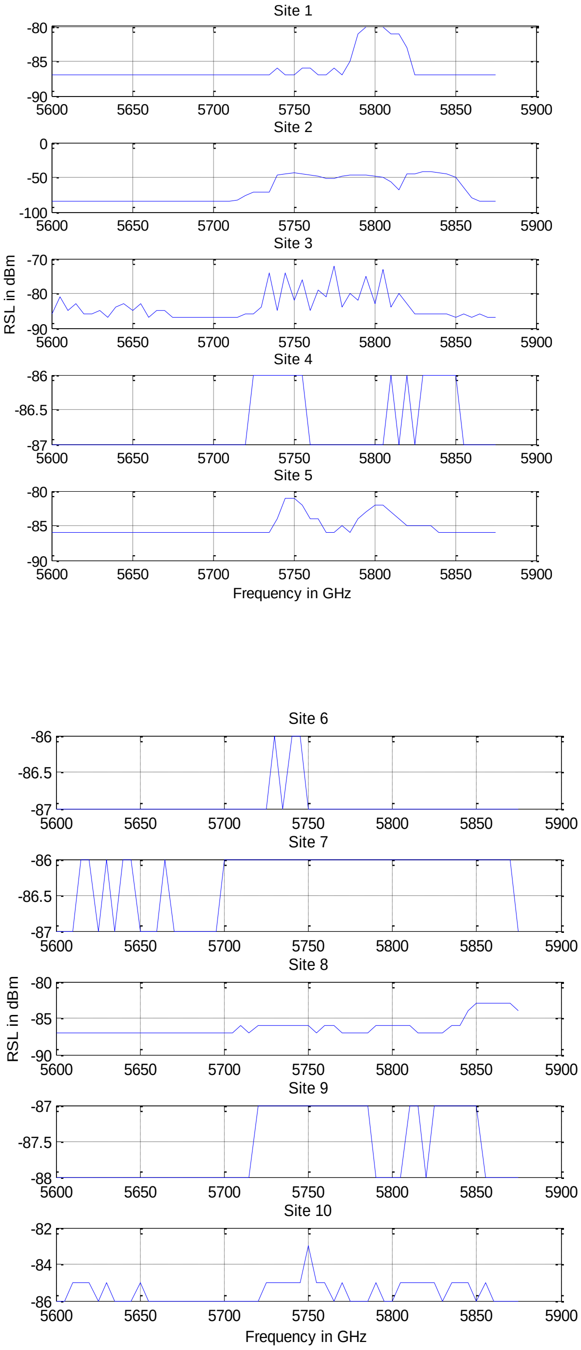

Fig.4: Statistical RSL from Site 1 to Site 10

Fig. 4 shows the variations in the receiver signals observed during the time of installation of the antennas for the wireless internet access in the subscriber locations. This monitoring process is good in determining the possible center frequency of the access point. However, when it comes to sensitivity determination, this may not be a good technique. Remember that sites number 1,2,6,7 and 8 are out of range from the 2km coverage area set by the ISP. These locations still give statistical patterns similar to the sites that are near the ISP transmitters but with very weak signal strengths. Choosing sensitivity from these signals will cause a scenario wherein you are connected to the link but you don't have enough signal strength to access the internet.

Table 3: Results for Manual Sensitivity Assignments

		RSL in dBm				
		Site1	**Site2**	**Site3**	**Site4**	**Site5**
Most power-ful trans-mitter	High-est	-81	-86	-72	-42	-79
	Low-est	-86	-87	-87	-83	-87
	Ave	-85.23	-86.75	-83.78	-67.35	-85.42
		Site6	**Site7**	**Site8**	**Site9**	**Site10**
Most power-ful trans-mitter	High-est	-86	-86	-83	-87	-83
	Low-est	-87	-87	-87	-88	-86
	Ave	-86.94	-86.27	-86.23	-87.61	-85.53

Table 3 shows the summary of the data from the monitored signals from ISP receivers during installation process. Each ISP transmitter is giving -23dBm of power in omnidirectional pattern. Received signals between -50dBm to -75dBm are considered "good signals" while signals from -80dBm and lower are considered to be "weak signals". The site engineer may choose whether he will assign the highest, lowest or the average monitored signal as the sensitivity of the receiver. If he chooses the smallest value, then everything above the level will be received by the receiver, even if these signals are just noise or multipath signals. If the site engineer chooses the highest monitored highest, then all incoming signals lower than that level will be discarded, leaving the link unavailable most of the time. One possible option for the site engineer is to choose the average monitored signal as the sensitivity of the receiver.

The installation process is usually done during normal weather conditions. The ISP seldom do the installation process during bad weathers or during heavy rains. This leads to a fact that the monitored signal levels during the time of installation of the receiver does not have any considerations with the degradation that will be caused by the rain events. This is the reason why most of the wireless links fail during heavy rain events.

The proposed solution for the sensitivity assignment problem is an artificial neural network which is also based on heuristic and past historical data from the monitored receiver signal signals. The comparison of results between the current method and the ANN algorithm is shown in table 3 below. Only the 5 stations that are within the 2km coverage area are used in this comparison. The average monitored signal is also shown as the chosen manual sensitivity.

Table 4: Comparison of Sensitivity Assignments between Manual and ANN methods

	Station Locations				
Parameter	**1**	**2**	**3**	**4**	**5**
Distance km	0.36	0	0.87	0.14	0.95
Manual Sensi-tivity	-87	-83	-87	-88	-86
ANN Sensitivity at 30oC	-75.04	-73.00	-86.35	-72.92	-84.55

5. Conclusion

Based on experiment results, the manual method of assigning the receiver sensitivity for wireless internet is very susceptible to human error and non-expertise of the onsite engineer. The choice of the weakest signal as the sensitivity of the receiver may cause the system to receive all signals at the receiver including multipath and noise signals. This scenario leads to a link which you may think is always connected due to the presence of received signals but does not have enough power and bandwidth needed in surfing the internet.

The proposed ANN has at least 90% accuracy in determining the receiver sensitivity during installation. This assigned sensitivity can compensate for the degradation of the received signals during extreme weather conditions. ANN can also detect out of range links and prohibits the system to received non-incident signals.

It is therefore recommended that the prosed system be implemented in a certain area of interest, monitor and analyse if there will be improvements in the link availability of the system specially during rain events or rainy days.

Acknowledgement

The researcher would like to thank the Department of Science and Technology Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD) for the financial assistance relative to the support of this conference. Also, to the sending institution, Xavier University – Ateneo de Cagayan, Cagayan de Oro City, Philippines.

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