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# Optimized Wireless Local Area Network Messaging System Using Swarm Intelligence

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***Abstract—****In this paper, optimization of intelligent WLLAN messaging system using ABC method is proposed. The system investigated the impact of optimizing (minimizing) path loss considering the ITU path loss model as well as adjusting ABC maxCycle parameter. The results of simulation studies indicated that in general, path loss values will reduce as the maxCycle parameter is gradually increased. Also, the shape of the fitness response plots will show a less random trend or pattern for the case of maxCycle parameter value equal to 25 when compared to that equal to 5. Hence, it is important to use a higher maxCycle parameter > 5 for optimizing WLAN messaging systems.*

***Keywords—*** *Fitness, Messaging, Optimization, Path loss, WLAN.*

## I. INTRODUCTION

Messaging plays a crucial role in any given society as the need to communicate is essential for normal business transactions, social interactions and remote functions and operations. Messaging is as old as man himself and has been communicated through voice, imaging (or visual signs) and through a variety of other physical media by wired or wireless means. The business of messaging in pre-historic times revolved around the use of some earlier forms of communication such as with floaters using the waterways to pass a message from one end of a place to another and by using a town crier within a locality. The invention of the Personal Computer and communications however, brought a change in the traditional or manual methods of messaging leading to more modern and advanced forms of passing across messages. Some of these innovations include the development of the e-mail for peer-to-peer and peer-to-all messaging and the short-messaging-service (SMS) for mobile messaging between clients and between clients and the operators. Some messaging systems are intended to run independently on a Local Area Network (LAN). Some of the advantages are increased privacy and faster speeds. However, one drawback with these systems is the recurring costs of maintenance added with initial high cost of installation and lack of flexibility. In a society where the increasing costs of operations in terms of installed facility and operating services mitigate seamless communication between clients, more cost-effective messaging environments are needed. One solution is through the use of WLAN. WLAN is a Wireless local area network (also called 802.11 network by the IEEE) specifically aimed at transmitting messages through a radio frequency channel within a few kilometers. This is especially useful for small to medium-size organizations where cost and the need for fast messaging systems are desired and very long-distance remote distance communications is not necessarily important.

However, with variations in propagation range of the wireless signal and the presence of unexpected structures, WLANs may suffer from the unwarranted path loss dilemma.

Thus, it becomes necessary to develop optimal solutions and algorithms that can greatly minimize if not avert the undesirable path-loss phenomenon.

Deploying an optimal messaging system for a WLAN will require the determination and computation of a number of operating parameters defined by certain boundary conditions. Some of these parameters either directly or indirectly influence the messaging performance of the WLAN and the associated parameters must be optimal to ensure a reliable operation of the WLAN station.

Optimal WLAN approaches are useful in the sense that they minimize the associated costs of running a system based on an objective function; the objective function in this may be the path-loss or any other primary parameter that must either be minimized or maximized to achieve desired operation.

More recently, renewed interest in intelligent approaches have been proposed for the design of intelligent optimal systems such as in (Noonan, 2013), using the JADE framework, intelligent approaches based on confidence levels (Tiernan et al, 2000) and Multi-Agents (Meech et al, 2000).

With the challenge of ensuring efficient message delivery, the task of optimizing the existing WLAN messaging system becomes a core requirement both for small and large corporations. Thus, intelligent messaging system is desired to handle such problem which is the basis of this research study.

## II. RELATED STUDIES

This section reviews related works in the area of optimization of radio propagation path-loss exponent models firstly in the widely used GSM networks and then in the Wi-Fi bands i.e. the IEEE 802.11 frequency spectrum.

### *2.1. Related works based on GSM Telecommunications*

Optimization of radio propagation path loss models is an active area of research. For GSM networks, this area of study is indeed very active with emphasis on improve the quality of



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service in the communication sector. However, in Wireless Local Area Networks (WLAN) very little research has been done on the optimization of Wi-Fi performance parameters.

In (Al Salameh and Al Zubi, 2015), the use of a particle swarm optimization (PSO) algorithm was proposed for GSM networks in Irbid, Jordan. PSO belongs to the class of swarm-based intelligence algorithms for optimizing a cost or objective function. In their study, the task was to fit the desired (measured) path loss values with a path loss propagation model (the Lee model) in the mean square error sense. Using the Root-Mean-Square-Error (RMSE) as fitness function, they tuned a set of three model parameters. Their results were compared with measured data and they were able to report up to 37 dB improvement for the optimized case.

Mardeni & Priya (2010) developed an optimal model using statistical techniques. In particular standard deviation analysis was performed to determine and validate the best model to select from a list of 3 well known path loss models. The approach was used in predicting path loss in a specific location in Malaysia. The results of their simulations show the Cost-231 Hata model to be the most suitable model for the study location.

In Nadir and Suwailam (2014), path loss prediction models have been performed using the Okumura-Hata model. This model was applied in the urban and semi-urban environments in Oman and comparisons were made with measured data. However, their models are not optimized in form and structure which means they may not be able to function effectively in diverse environmental settings.

Sah and Kumar (2009) used the constraint satisfaction programming (CSP) algorithm for predicting and optimizing path loss in wireless empirical propagation (WEP) models. In terms of path loss evaluation, the CSP is basically an iterative algorithm wherein the WEP model can be stated as a CSP problem (CSPP or $CSP^2$) and the result optimized using a constraint satisfaction optimization (CSO) algorithm. In their experimental investigations they proposed a solution to the CSP using the chronological back-tracking algorithm (CBTA). Their objective was to find the optimum set of base station parameters for which the path loss is a minimum. They then applied the CSP algorithm to 6 WEP models with a minimum path loss reported for all models.

Jadhav and Kale (2015), developed an optimized path loss model for the Maharashtra city in India using different path loss models. Their model fitting process was described as a sum-of-deviation squares function for which the minimum (least) state is desired. The optimized Cost-231 Hata model was shown to be the most suitable and was further optimized. The authors reported accuracies of between 25-40%, a smaller path loss and path loss exponent compared to the standard Cost 231 Hata model.

The use of the ABC algorithm was explored in Singh and Kaur (2013) for optimizing base transceiver locations (BTSs). Their idea is to determine the minimum number of BTSs based on their location(s) that can serve a large number of subscribers at lower infrastructural cost. Thus, the ABC algorithm tries to look into the future for the optimal set of BTS locations and in turn, the best BTS from an ensemble of BTSs. Their proposed approach was compared with the K-means clustering algorithm with lower path loss obtained for the ABC algorithm while K-means had lower transmit power.

Thus, our primary purpose in this study is to investigate the effectiveness of ABC as an optimizing tool in path loss minimization using readily available local data.

### *2.2. Related works based on WLAN (Wi-Fi) Systems*

Path loss models for GSM networks are very popular so it is important we discuss related works in this area of study. However, very little attention is given to WLAN networks. This research will also attempt to address this gap by presenting related works in the field of path-loss modeling for WLAN networks. In attempting to bridge this gap, the importance of WLAN path loss models will be stressed.

In Plets et al (2012), a heuristics algorithm based on a multidimensional optimization process that searches for the minimum path loss taking into account several categories of losses is proposed.

Konak (2010) proposed the Kriging technique for predicting the path loss at a given location considering an initial training set of path-loss-location data examples; the Kriging method was initially developed in (Krige, 1951; Matheron, 1963) and minimizes a certain Kriging error using the Langrangian Multiplier.

In Rath et al (2017) a stochastic statistical model is proposed for predicting the path-loss in the Industrial Scientific and Medical (ISM) under varying real time indoor situations. Experiments including bi-weekly drive tests were performed by the authors in which the first week was used for model fitting and other week for validate. They reported comparable results with the two popular WLAN path loss models and showed that the proposed technique have better mean-squared-error (MSE) performance than the other two techniques.

In Plets et al (2012), a simple generalized path loss model based on the Indoor Dominant Path-loss technique (IDP) is proposed for dealing with the site specific challenges faced by the existing path loss model.

Safna et al (2015) recommended the use of a modified Joint Technical Committee (JTC) WLAN path loss propagation model. The modified JTC allows for optimization to any given condition. They reported better fitting using the proposed modified technique when compared to the original JTC path-loss model.

In Al-Mamun et al (2016) an optimization technique is proposed to minimize the number of active heterogeneous access points (AHAP) within an elastic WLAN system model. Their proposed technique accounts for the network topology and the user requirement i.e. user demands. If we add path-loss to the AHAP difference, we get a Cumulative Objective Function (COF) i.e. we may want to minimize the estimated path-loss in addition to the number of AHAPs

## III. METHODOLOGY

The approach to solving the WLAN optimization is based on the use of Swarming Artificial Intelligence (SAI) technique. The SAI technique considered in this context is the



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Artificial Bee Colony (ABC) developed by Karaboga (Karaboga, 2005).

### 3.1. Path-Loss Minimization Using ABC Algorithm

The ABC approach to path loss minimization, provides a simple but yet highly efficient step towards global optimization. The details of the ABC algorithm and the path loss minimization problem are discussed in the following sub-sections.

### 3.2. The ABC Algorithm

ABC was invented by Karaboga in the mid 2000's. It is a swarm inspired evolutionary computing tool based on foraging behavior of honey bees; it is also a device, technique and approach to everyday optimization problem. ABC is well suited to task that requires a minimization function set though a maximization functionality may also be incorporated into the original ABC code of the authors. The ABC algorithm basically employs three core phases (see Figure 1):

Employed Bees Phase – where a population of food points generated is exploited by a probabilistic population of swarms (bees) with information sharing capability.
Onlooker Bees Phase – whereby the bees search for the best sources of food
Scout Bees Phase – to search for new sources of information

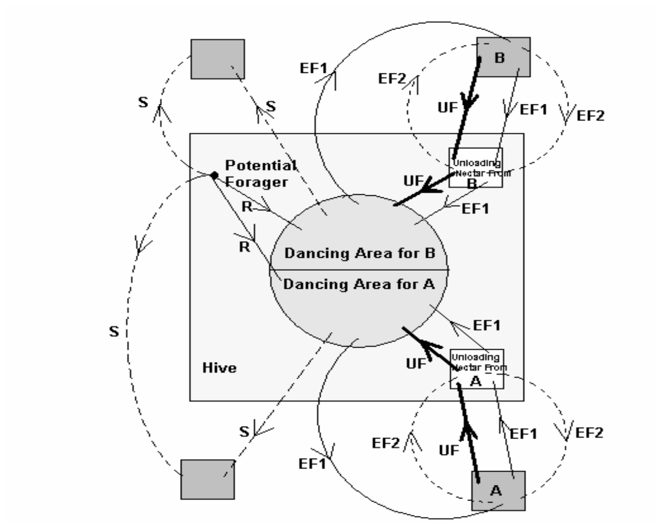


Figure 1: The Foraging behaviors of honey bees; Source: Karaboga (2005)

### 3.3. The Path-loss Minimization Problem (PMP)

Since path loss plays a crucial role in the determination of the quality of service (QoS) of a mobile systems operator, its problem needs to be clearly stated in order to define clearly the modus operandi anyone GSM operator. In this study, the PMP is defined as the task of obtaining the right set of mobile BTS operating parameters that fit a pre-specified theoretical model to empirically observed data in the least squares sense.

### 3.4. Fitness function

Fitness function is based on the ITU path loss model for indoor Wi-Fi Wireless Local Area Networks (WLANs) which is expressed as:

$$PL_{ITU-R}(dB) = 20 \times \log 10(f) + N \times \log 10(d) + P_f(n) - 28, \quad (1)$$

where,
$f$ = operating frequency in MHz
$N$ = distance power loss coefficient
$d$ = distance between transmitter and receiver in meters
$Pf(n)$ = floor loss prediction factor
n = number of floors between transmitter and receiver.

## IV. Results and Discussions

Simulations have been performed with Channel 1 setting of the WLAN to determine the path loss behavior under varying parameter configurations using the MATLAB programming language.

Specifically, the influence of maxCycle parameter of the ABC algorithm on the path loss is investigated. The default "maxCycle = 5;" is changed to a higher value, say 10. Then the simulation is run and results recorded. The aforementioned operation is repeated until the desired numbers of increments are attained.

### 4.1. Simulation Results by varying the maxCycle parameter

The estimated path loss values of varying the ABC maxCycle parameter for different values from a setting of 5 to 25 and in increments of 5 are as shown in Table 1.

The ABC runtime parameter has been fixed at a value of 20 to allow for twenty independent trial runs. All other parameters have also been fixed.

TABLE 1. Path loss for different setting of the ABC

| maxCycle value | Path loss (dB) |
|---|---|
| 5 | 183.6115 |
| 10 | 187.4380 |
| 15 | 180.5869 |
| 20 | 178.0833 |
| 25 | 172.4221 |

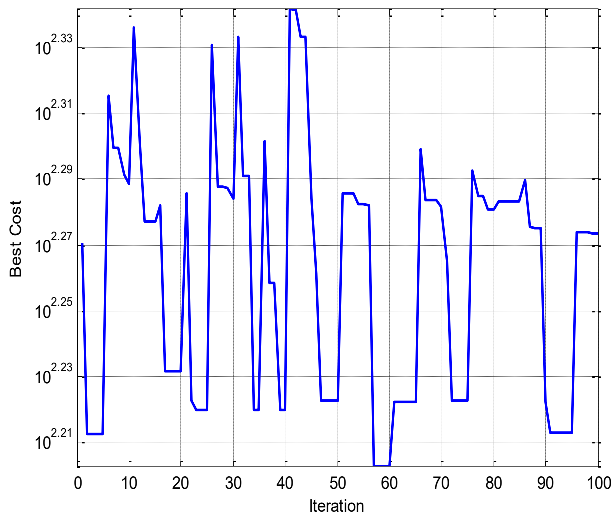


Figure 2: Fitness plot for the WLAN model with a maxCycle set to 5



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In Figures 2 and 3 also captures the fitness values response of the ABC algorithm when maxCycle parameter is set to 5 and 25 respectively.

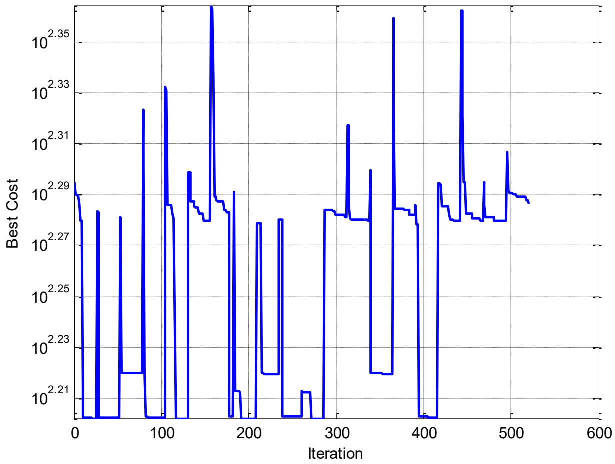


Figure 3: Fitness plot for the WLAN model with a maxCycle set to 25

### *4.2. Discussion of Results*

Results of tests have been tabulated in Table 1 and are also reported in Figures 2 and 3. The results indicate that in general, the path loss values will reduce as the maxCycle parameter is gradually increased. Also, the shape of the plots show a less random trend or pattern for the case of maxCycle parameter value equal to 25 when compared to that equal to 5.

## V. Conclusions

In communications field, the path loss model is very useful for predicting various coverage areas, interference analysis, frequency assignments and cell parameters in which are all fundamental elements for the network planning processes in mobile radio systems – particularly in WLANs. This would pose benefits for telecommunication providers to further improve their services in serving high signaled quality coverage for mobile users whilst increasing the capacity in urban areas. The model can be equally made more useful for telecommunication and Wi-Fi providers by incorporating AI techniques.

This research study attempts to solve the PLM problem using an emerging Swarming AI (SAI) based algorithm based on swarm of bees operation called the ABC. The system used the MATLAB programming language for developing the application and simulations showed the importance of increasing max_cycle parameter to reduce the loss.

It is recommended to have further intensive study in other areas in communication network such as congestion control system and interconnectivity in the future. There are more typical environments that are not covered in this research study. The measurement data should be collected from diverse WLAN sites in different locations.

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