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Improving Noise To Signal Ratio In Smart Antenna Using Modified Artificial Bee Colony

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Abstract

Recent days, number of subscribers in cellular communication is very huge and hence the cellular communication becomes the most augmented technical field in all over the world. Therefore, to provide low cost, high quality and comparatively better data rates are major requirement of cellular providers. Hence, deployment of smart antenna systems throughout major metropolitan cellular markets is the major concern in nowadays. Smart antennas are implemented with multi-beam technologies, which proved substantial performance improvements in FDMA, TDMA and CDMA networks through extensive analysis, simulation, and experimentation. Still, improving noise to signal ratio is the major research issues in smart antenna. This paper proposes modified artificial bee colony algorithm for improving noise to signal ratio in the smart antenna. The artificial bee colony is a swarm intelligence algorithm and an optimization technique which is evolved from behavioural aspects of the real bee colony. Swarm intelligence is a growing field of study that consists of many optimization techniques which simulates the intelligence of animals, birds and insects such as ant colony optimization.

Keyword: Wireless Networks, Cellular Communication, Smart Antenna, Multi-Beam

1. INTRODUCTION

Smart Antennas in mobile communications enhances the capabilities of the mobile and cellular system such as faster bit rate, multi use interference, Space Division Multiplexing Access (SDMA), adaptive SDMA, increase in range, multipath mitigation, reduction of errors due to multipath fading, best suitability of multi-carrier modulations such as OFDMA. The major advantages of Smart Antennas are it suite well for demand based frequency allocation in the hierarchical system approach. The major challenge to reduce the co-channel interference (Chandramohan et al, 2011a) is to realize the algorithms found in research to implement in the hardware. By introducing an array with N antennas, the amount of hardware equipment is expected to increase in N times. In order to avoid such cost, the smart antennas are proposed. Therefore, flexible antenna pattern are achieved electronically and no physical movement of receiving antennas is necessary (Chandramohan et al, 2011b).

Smart antennas are most appropriate for use of cognitive radio (software radio technology provides flexibility) and the greatest advantage of smart antenna is a very high security. The main impediments to high-performance wireless communications are interference from other users (co-channel interference), the inter-symbol interference (ISI) and signal fading caused by multipath. Co-channel interference limits the system capacity, defined as the number of users which can be serviced by the system.

However, since the desired signal and co-channel interference typically arrive at the receiver from different directions, smart antennas can exploit these differences to reduce co-channel interference, thereby increasing system capacity. In a cellular system, omni-directional antennas have traditionally been used at base stations to enhance the coverage area of the base stations but it also leads a gross wastage of power that in-fact is the main cause of co-channel interference at neighboring base stations. The sectoring concept with diversity system exploits space diversity and results in improve reception by counteracting with negative effects of multipath fading.

Adaptive / smart antenna technology represents the most advanced smart antenna approach to date. Using a variety of new signal-processing algorithms, the adaptive system takes advantage of its ability to effectively locate and track various types of signals to dynamically minimize interference and maximize intended signal reception. Both adaptive / smart systems attempt to increase gain according to the location of the user; however; only the adaptive system provides optimal gain while simultaneously identifying, tracking, and minimizing interfering signals (Misran et al, 2008).

2. RELATED WORK

In actual, antennas are not Smart Antenna, systems are smart. Generally co-located with a base station, a smart antenna system combines an antenna array with a digital signal-processing capability to transmit and receive in an adaptive, spatially sensitive manner. In other words, such a system can automatically change the directionality of its radiation patterns in response to its signal environment. This can dramatically increase the performance characteristics,such as capacity of a wireless system (Najashi et al, 2011).

The antenna could optionally be any sensor. Smart antenna techniques are used notably in acoustic signal processing, track and scan Radar, Radio astronomy and Radio Telescopes and mostly in Cellular Systems like W-CDMA and UMTS (Palaniswamy et al, 2013). A smart antenna enables a higher capacity in wireless networks by effectively reducing multipath and co-channel interference. This is achieved by focusing the radiation only in the desired direction and adjusting itself to changing traffic conditions or signal environments. Smart antennas employ a set of radiating elements arranged in the form of an array.

An adaptive algorithm controls the weights according to predefined objectives. For a switched beam system, this may be primarily maximum gain; for an adaptive array system, other factors may receive equal consideration. These dynamic calculations enable the system to change its radiation pattern for optimized signal reception.

Song et al (2001) analysis the performance of smart antenna algorithms when used in code-division multiple access (CDMA) wireless communication systems. Complex pseudo noise (PN) spreading, despreading, and pilot-aided channel estimates in the cdma2000 reverse link are some of major characteristics that are different from those in the IS-95 CDMA systems.

The adaptation of smart antenna techniques in future wireless systems is expected to have a significant impact on the efficient use of the spectrum, the minimization of the cost of establishing new wireless networks, the optimization of service quality, and realization of the transparent operation across multi technology wireless networks. Nevertheless, its success relies on two considerations that have been often overlooked when investigating (Alexiou et al, 2004) smart antenna technologies: first, the smart antennas features need to be considered early in the design phase of future systems (top-down compatibility); second, a realistic performance evaluation of smart antenna technique needs to be performed according to the critical parameters associated with future systems requirements (bottom-up feasibility). In this article an overview of the benefits of and most recent advances in smart antenna transceiver architecture is given first.

In 2005, Rezk et al (2005) investigated and compared the performance of a newly proposed hybrid smart antenna system with the fully adaptive and switched beam smart antenna arrays. Simulation results show that the adaptive and the proposed hybrid systems have nearly the same performance accuracy, with the hybrid system offering faster tracking time, improved computational efficiency, and a possible reduction in the implementation cost. The comparative study also included measured radiation pattern from a recently developed coplanar waveguide continuous transverse stub (CPW-CTS) antenna.

The use of smart antennas in multihop wireless networks has garnered significant attention over the last few years. Given the unique capabilities of smart antennas, and how they can improve performance in a typically constrained multihop wireless network (MWN) environment, the attention is with merit. However, not much light has been shed on MWNs that have nodes with varying antenna capabilities. While homogeneous MWNs with all nodes having the same antenna capabilities will have certain applications, MWNs with nodes having heterogeneous antenna capabilities are more likely to be the norm due to a variety of motivating factors (Sundaresan et al, 2011).

One of the most important processes in smart antennas, is beam forming. The major function of beam forming is to change the beam pattern of the antenna for a given angle. If the antenna does not change its direction based on the receiving signal, the signal losses will be high. So, in order to increase the efficiency and to reduce the signal losses in the system, a new method is proposed byGhouse Basha et al (2012) for beam forming in smart antenna along with spatial diversity using fuzzy interference system and neural network (NN).

3. PROPOSED MODIFIED ARTIIFICIAL BEE COLONY ALGORITHM

Swarm intelligence is a new discipline of study that contains a relatively optimal approach for problem solving which are the imitations inspired from the social behaviour of insects and animals, for example, Ant Colony Optimization (ACO) algorithm, Honey Bee Algorithms, Fire Fly Algorithm. The “ACO Algorithm” is a study derived from the observation of real ants’ behaviour, and uses these models as a source of inspiration for the design of novel algorithms, which is the solution for optimization and distributed control problems. The Honey Bee Mating algorithm is the growing technique, which is proposed in late 2005, for many engineering applications.

To identify the optimal location of bio-mass power plant (David et al 2010), Constraint Optimization Problem (Dervis and Behriye, 2009), data Clustering in data mining (Dervis and Celal 2011) and Path management in the computer network are some of the successful solutions based on ABC algorithm. The detailed honey bee mating algorithm is explained.

The algorithm requires a number of parameters to be set, namely: number of scout bees (n), number of elite bees (e), number of patches selected out of n visited points (m), number of bees recruited for patches visited by "elite bees" (nep), number of bees recruited for the other (m-e) selected patches (nsp), size of patches (ngh) and stopping criterion. The algorithm starts with the n scout bees being placed randomly in the search space.

The bees search for food sources in a way that maximizes the ratio

$$F(\theta) = \frac{E}{T} \qquad (1)$$

Where, E is the energy obtained, and T is the time spent for foraging. Here E is proportional to the nectar amount of food sources.

In a maximization problem, the goal is to find the maximum of the objective function F (θ), $\theta \in R^P$. R^P represents the region of search area.

Assume that θ_i is the position of the i^{th} food source; F (θ_i) represents the nectar amount of the food source located at θ_i and it is proportional to the energy E (θ_i).

Let $P(C) = \{\theta_i(C) \mid i = 1, 2... S\}$ represent the population of food sources being visited by bees, in which, C is cycle, and S is number of food sources around the hive. The preference of a food source by the worker bee depends on the nectar amount F (θ) of that food source. As the nectar amount of the food source increases, the probability with the preferred source by the worker bee increases proportionally. Therefore, the probability with the food source located at θ_i will be chosen by a bee can be expressed as

$$P_i = \frac{F(\theta_i)}{\sum_{k=1}^{s} F(\theta_k)} \qquad (2)$$

The position of the selected neighbour food source is calculated as the following:

$$\theta_i(C+1) - \theta_i(C) \qquad (3)$$

and the stop criteria of the system is

$$N_i(Q) - N_i(E) \geq H_{th} \qquad (4)$$

where,

N_i (Q) represents the values of nectar of Queen,

N_i (E) represents the values of nectar of Elite bee, and H_{th} represents the minimum threshold value of the Hive.

At the end of iteration, the colony will have two parts to its new population - representatives from each selected patch and other scout bees assigned to conduct random searches.

The design and working nature of the proposed MABC is redefined in order to provide optimality. The existing ABC has few pitfalls such as the improper number of scout bee will lead local optimal problem and slow convergence. Therefore the MABC fine-tuned performance metric and redefined the parameters which lead to such pitfalls. In the following section, the formation of elite bee and routing decision model is described.

The proposed algorithm requires only two parameters to be set, namely the number of scout bees (n) and 'ngh' is the size of the patch. The n is equal to number of flowers (Signal to Noise Ratio) in the garden (smart antenna). Suppose, the number of scout bees is less, the efficiency of Signal to Noise Ratio(SNR) becomes less. Vice versa, the number of scout bees is more, the efficiency is improved but time to evaluate SNRis increased. Therefore, in the proposed work, the number of scout bees is defined as number of nodes in the network or sub-network. This value is a trade-off between efficiency and routing cost.

The size of patch is represents number of cluster in the smart antenna. The bees search for food sources in a way that maximizes the ratio

$$\forall(E,H) \Leftrightarrow F(\theta_i) = \frac{SNR}{H} \tag{5}$$

Where, SNR is the signal to noise ratio of the concern antenna, H is the hop count between transmitter and the antenna. In a maximization problem, the goal is to find the maximum of the objective function, F(θ). F(θ) is the nectar ratio, shown in equation (5), $\theta \in R^P$. R^P represents the region of search area. Assume that θ_i is the position of the i^{th} food source; $F(\theta_i)$ represents the nectar ratio of the food source located at θ_i and it is proportional to the energy $E(\theta_i)$.

If the nectar ratio, F(θ), of the food source is higher than minimum threshold, then the scout bee initialises the waggling dance with rhythm above the food source (which is called as dance floor). This waggling dance is a visualization technique that to transfer information to the in-sight worker bees. If the worker bees are beyond in-sight, the rhythm of scout bee may reach the worker bee. Based on the visual and or audio information from the scout bee, the worker bee from one hive or more hives will reach the dancing floor (food source) for collecting the nectar.

$$T(\theta_i) = \begin{cases} \alpha \bullet F(\theta_i) & F(\theta_i) > F_{th} \\ 0 & \text{otherwise} \end{cases} \quad (6)$$

$$R(\theta_i) = \begin{cases} \beta \bullet F(\theta_i) & F(\theta_i) > F_{th} \\ 0 & \text{otherwise} \end{cases} \quad (7)$$

where the $T(\theta_i)$ is the duration of waggling dance, $R(\theta_i)$ is the volume of rhythm, F_{th} is the minimum threshold of the nectar value and α, β are the constant which is termed as time scale factor and volume scale factor.

$$0 < \alpha < 1 \quad (8)$$

$$0 < \beta < 1 \quad (9)$$

If the value of α and β are small, then convergence become fast. If the value of the same is high, more precise result will occur. The bees search for food sources and collect the nectar (E). This process initiates the waggling dance in the floor for T time units (based on the equation 6) with R volume of rhythm (based on the equation (7)).

If the dancing time of bee is elapsed, then it will search the neighbouring dancing bee and goes to the dancing floor of neighbouring bee to watch the dance as guest bee. Suppose more than one dancing bee found near, then the bee choose the one with higher rhythm (Rhythm of bee proportional to nectar).

4. RESULTS AND PERFORMANCE ANALYSIS

The proposed MABC is implemented in Network Simulator 2 (NS2), and the performance is tested in variety of design and topology of networks; in variety of network design which based on number of antennas; ranges of signal; and using variety of services. Table 1 shows the channel characteristics used for simulation and Figure 1 shows the Time of Arrival (ToA) vs power of smart antennas.

Table 1. Channel Characteristics of Micro Cell Smart Antenna

d_{MT} [m]	σ_τ [μs]	$\sigma_{\phi,NB}$ [°]	$A_{scat.\ ellipse}$ [km²]
50	0.39	44	0.182
500	0.18	32	0.261
1 000	0.10	23	0.418

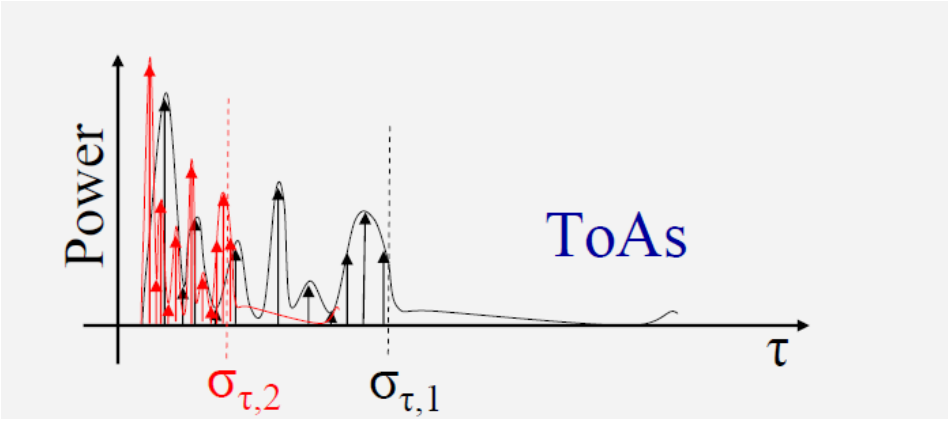

Figure 1. Performance of Time of Arrival (ToA)

From the Figure 1, it is understood that the smart antenna is increased range and the potential to introduce new services. Major drawbacks and cost factors include increased transceiver complexity and more complex radio resource management. In the Smart antenna, special attention is given to the critical factors and technological challenges, including achieving equal performance on uplink and downlink as well as real-time calibration of the receiver and transmitter chains.

Today, handset manufacturers are seeking an effective antenna solution suitable for implementing the next generation of cellular handset technologies, known as Long Term Evolution (4G LTE). Currently, they are unable to achieve physically the desired antenna performance in a size that fits a cellular handset package at an acceptable volume cost. Current implementations from the leading handset manufacturers employ typically six antennas. The highly compact SAT technology replaces all existing antennas—DVB-H, Bluetooth, Wi-Fi, GSM, GPS, 3G multi-bands and 3.9/4G LTE—with just one. This single SAT device provides significantly lower costs, is smaller in size and offers much needed performance gains over existing designs and technology.

Figure 2 and 3 represents the SNR on improving time period in correlated fades and uncorrelated fades.

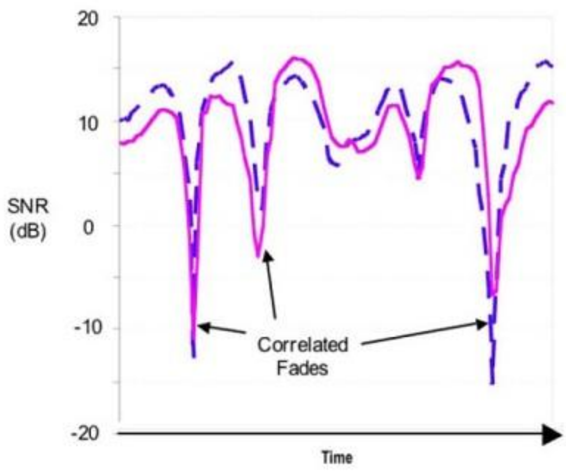

Figure 2. SNR vs Time – Correlated Fades

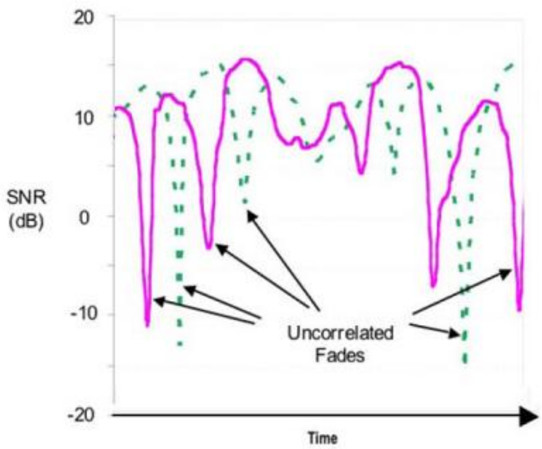

Figure 2. SNR vs Time – Uncorrelated Fades

5. CONCLUSION

The results of proposed work in correlated and uncorrelated fades are verified on existing and proposed works. The SNR of proposed work is improved better than existing methodologies.Smart Antennas have been tested in a variety of field locations with promising results. The new antenna has demonstrated a considerable advantage over various indoor antennas with no amplification and the set-top UHF loop/VHF rod antenna combination with built-in amplification. In a few locations, Smart Antennas may be unable to automatically optimize the signal.

Smart Antenna systems capture, convert and modulate analog signals for transmission as digital signals and reconvert them to analog information on the other end. In adaptive antenna systems, this fundamental signal-processing capability is augmented by advanced techniques (algorithms) that are applied to control operation in the presence of complicated combinations of operating conditions. The dual purpose of a smart antenna system is to augment the signal quality of the radio-based system through more focused transmission of radio signals while enhancing capacity through increased frequency reuse. The technology of smart or adaptive antennas for mobile communications has received enormous interest worldwide in recent years.

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