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A Novel approach for Optimizing Cross Layer among Physical Layer and MAC Layer of Infrastructure Based Wireless Network using Genetic Algorithm

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***Abstract*— Cross-layer awareness optimization is a break out from the layered approach of the OSI Layer communications model having very rigorous boundaries among layers. The CLAO approach transports response dynamically via the layer boundaries. Due to input from one layer to another layer it affects the later layer with its deficiency. In this work Smart Antenna are used at Physical layer for optimization among the cross layers and Genetic Algorithm is used for optimizing the cost function.**

***Index Terms*—Cross Layer, Smart Antenna, GA**

I. Introduction

Cross-layer awareness optimization is a break out from the layered approach of the OSI Layer communications model having very rigorous boundaries among layers. The CLAO approach transports response dynamically via the layer boundaries. Due to input from one layer to another layer it affects the later layer with its deficiency. The strict boundaries create dependency problem for the concerned layer as well as other layers. The prime question arises whether this attitude can be applied to wireless infrastructure based network to map different layer (PHY and MAC layer) of protocol stack in cross layer framework. Now the optimization algorithm becomes the prime feature for optimizing among the Physical (PHY) and MAC layer.

Smart Antenna is used at physical layer for optimization. The term “smart antenna” refers to antennas array, processed using signal processor, which adapt signal to form beam pattern to point out desired signals and to minimize interference signals.

Genetic algorithm (GA) is nature inspired biological algorithm motivated from working of genetics. Genetic Algorithm falls under the category of Evolutionary Algorithm which follows working of genomes. We are using this algorithm for optimization our problem of minimizing the cost function.

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II. Cross Layer Optimization

Cross-layer awareness optimization is a break out from the layered approach of the OSI Layer communications model having very rigorous boundaries among layers. The CLAO approach transports response dynamically via the layer boundaries. Due to input from one layer to another layer it affects the later layer with its deficiency. The strict boundaries create dependency problem for the concerned layer as well as other layers. The prime question arises whether this attitude can be applied to wireless infrastructure based network to map different layer (PHY and MAC layer) of protocol stack in cross layer framework. Now the optimization algorithm becomes the prime feature for optimizing among the Physical (PHY) and MAC layer.

Few researches also showed optimization approaches for resource allocation problems in wireless systems. Illustrating the use of optimization approach for two classes of cross-layer problems, namely, the opportunistic scheduling problem in cellular (or access-point based single-hop networks), and the joint congestion-control and scheduling problem in multi-hop wireless networks. Convex programming is an important tool for this optimization approach; in particular, Lagrange duality is a key tool in decomposing the otherwise complex optimization problem into easily-solvable components.

Energy Consumption is area of recent research and requirement of time since consumption is affected by all layers of system design, ranging from silicon to applications. Energy efficient design requires a Cross Layer approach. Guowang Miao presented a very good comprehensive overview focusing on system based approach towards optimal transmission and resource management. Few researchers have also tried to resolve conflicts for solving scalability, lifetime for wireless sensor networks and also solving the bandwidth, power consumption, and node resource limitation. They prefer CLO as a promising solution for it.

Cross Layer perspective is also being used for improving the Quality of Service (QoS) required by delay-sensitive and high-bandwidth application by using a content-aware cross-layer (Application and MAC) packetization and retransmission strategy for optimized multimedia transmission over the wireless network.

III. Smart Antenna

The term "smart antenna" refers to antennas array, processed using signal processor, which adapt signal to form beam pattern to point out desired signals and to minimize interference signals. Fig. 1 showing M element smart antenna, having Digital Signal Processor (DSP).

Beam formed adaptive antenna systems allow the antenna with nulling interference signals and steering over the interested direction beam. The smart antenna concept is different from fixed beam "dumb antenna," which does not adapt its radiation power pattern with changing EM environment.

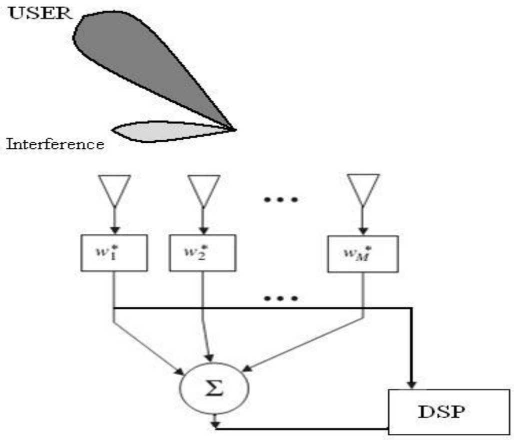

Fig. 1M-Element Smart Antenna

An adaptive antenna is an antenna that controls its own pattern, by means feedback control, while the antenna operates. Adaptive antennas are useful in radar and communication systems that are subject to interference and jamming. These antennas change their patterns automatically in response to the signal environment. They do so in a way that optimizes the SINR ratio at the array output. They are especially useful for protecting radar and communication systems from interference when arrival direction to the interference is not known in advance. Fig. 2 showing sectorized Smart Antenna.

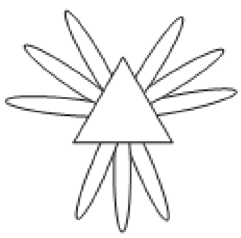

Fig. 2Smart Antenna Sector

IV. Genetic Algorithm

Genetic algorithm (GA) is nature inspired biological algorithm motivated from working of genetics. Genetic Algorithm falls under the category of Evolutionary Algorithm which follows working of genomes. It follows the law of genomes inheritance, mutation, selection and crossover (or recombination).

Genetic Algorithm Working

GA is very good alternative over the conventional method of optimization as it studies inheritance, selection, mutation and crossover. GA is implemented using set of initial input variables representing *chromosomes* consisting of given genes or individual values for obtaining better solution.

Solutions can be in form of Binary Strings of 1s or 0s or in other encoding form. These set of *chromosomes* form the *population* of randomly selected variables after each generation. Fitness of each variable is evaluated in population and being selected to form new population. This population is used in next phase of algorithm which executed to produce maximum iteration or fitness level reached up to mark.

With maximum number of iteration, we may or may not get desired solution. After defining fitness cost function, GA starts working by initializing population with chromosome evaluation and improving it with iterative process of mutation, selection and crossover operation.

Initialization of Population: Population represents matrix formation of chromosomes where each row represents chromosome and each chromosome having number of genes or variables.

*Evaluation of Chromosome:*The chromosomes are passed to fitness function for evaluation. The function defines range for chromosome as high and low value for evaluation.
Selecting the fittest chromosome helps in forming next generation for further iteration.

Crossover Selection and Mutation: The high probability next generation population is selected using crossover (or recombination).The healthiest members is selected from matrix pool for mating. From Roulette Wheel Selection or Tournament Selection the pair of parents formed for mating. Selected parents mate to form the offspring. Using several ways selected parents generates offspring or child. This generation varies from initial one. This increases the average fitness, since only healthy genes are selected for mating and generating offspring for next generation.

Termination: The above process repeated until meet the termination condition. Few conditions for terminations are as follows:

- Number of Generations reached
- Solution satisfying minimum required criteria
- No change in solution after maximum number of iterations

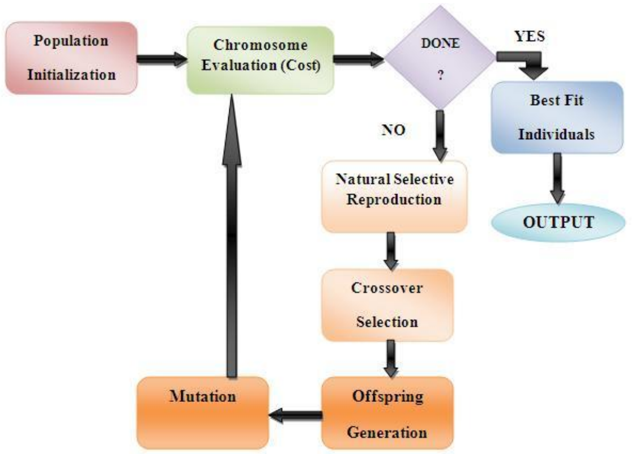

Fig. 3Proposed Continous Genetic Algorithm

Fig 3. shows the proposed Continuous Genetic Algorithm which is very robust for optimizing the cost function. CGA is very efficient for working over the real values or floating point values.

V. IMPLEMENTATION

We are proposing Continuous Genetic algorithm which is very powerful and robust for optimizing the cost function. Continuous Genetic Algorithm works over the continuous value like real values or floating point number. Continuous GA does not require conversion as done in Binary Genetic Algorithm for evaluating cost function and it is faster than Binary GA.

We are optimizing the array factor of smart antenna which plays very crucial role in forming the beam pattern of signal. We are optimizing this array factor using the Continuous Genetic Algorithm and showing its effect with variable element spacing.

Cost Function

$$af(u) = \sum_{n=1}^{N} a_n e^{jkx_n u} \quad (1)$$

where x_n= Element Spacing
k= Wave Number
u= cos (φ)

We are using Single Point Crossover for offspring Generation and Roulette Wheel Selection for mating in Continuous Genetic Algorithm.

Continuous Genetic Algorithm

Step1: Selecting CGA parameters and Defining Cost Function

In this step we define the variables used while optimization and defines the cost function in MATLAB code for optimizing using CGA.

Step2: Natural Selection of chromosome is done for mutation process

Step3: Parents Selection

Using the Roulette Wheel Selection for parent selection where parents are assigned probability for being selected.

Step4: Offspring Generation

By using Single point crossover we get the offspring matrix. Here each value of parents is being masked in 0s and 1s for processing.

Step5: Mutation

Now the random values are processed in population. The mutation rate defines the changed bits or values in a population. In our case, the mutation rate is 15%.

The simulations are performed using MATLAB. The CGA is applied to minimize the cost function which places the null with phase only weighting with varying element spacing.

For finding the fittest solution using the CGA we only use 50% of best fittest value for next step and discarding the remaining 50% value. Mutaion rate is 15% for CGA algorithm.

Table 1: Parameters table

Parameter	Value
Array Element	20
Minimum Cost	-50
Number of Generations	250
Function Call	250
Mutation Rate	15%
Initial Population	8x10 matrix
Discard Rate	50%

We have taken the 20 linear array element which forms the smart antenna.

Defining the -50 as minimum cost where cost function cannot reduce below the -50 value.

Optimizing the array factor for 250 generations using 250 function calls for minimization of (1).

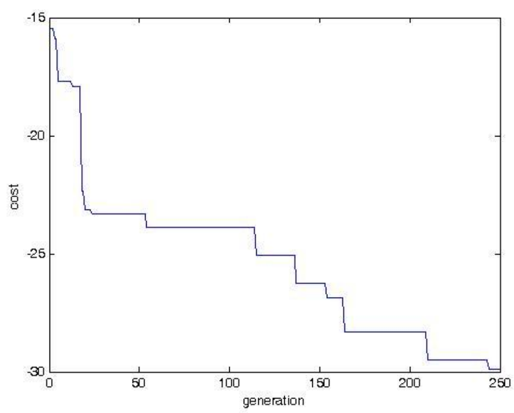

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Fig. 4Optimized Array Factor for element space d=0.5

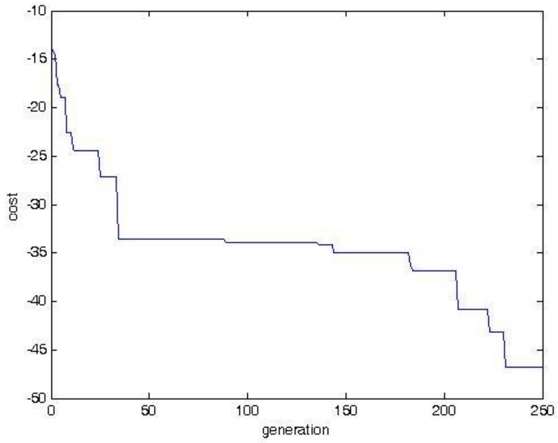

Fig. 5Optimized Array Factor for element space d=0.2

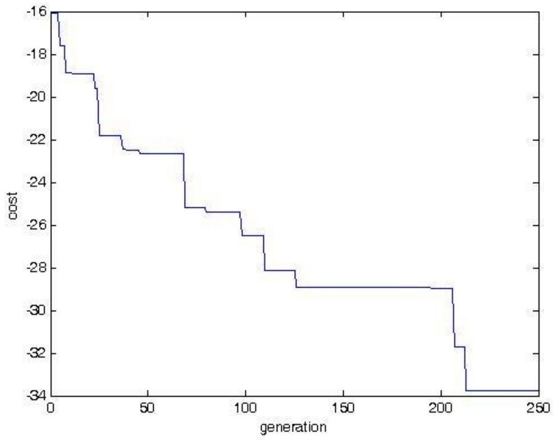

Fig. 6Optimized Array Factor for element space d=0.3

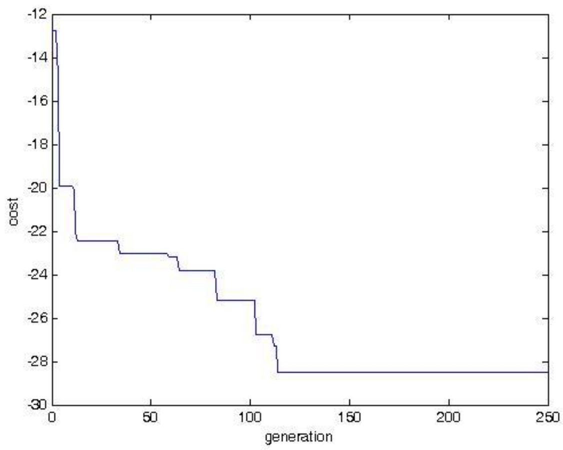

Fig. 7Optimized Array Factor for element space d=0.7

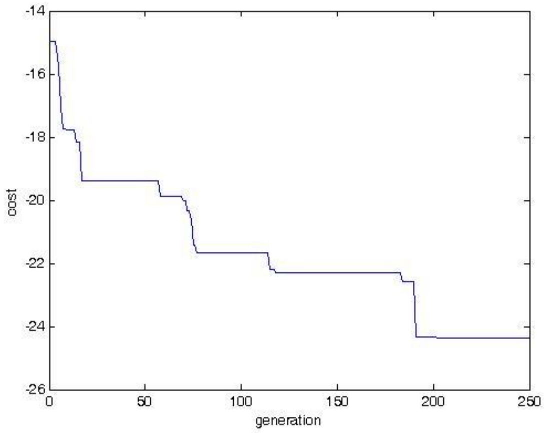

Fig. 8Optimized Array Factor for element space d=0.9

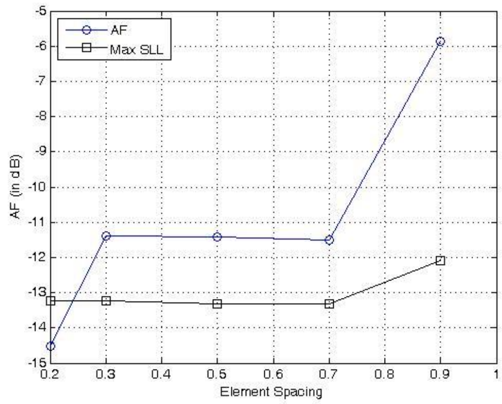

Fig. 9Array Factor value with respect to the maximum sidelobe level value for element spacing 0.2, 0.3, 0.5, 0.7, 0.9.

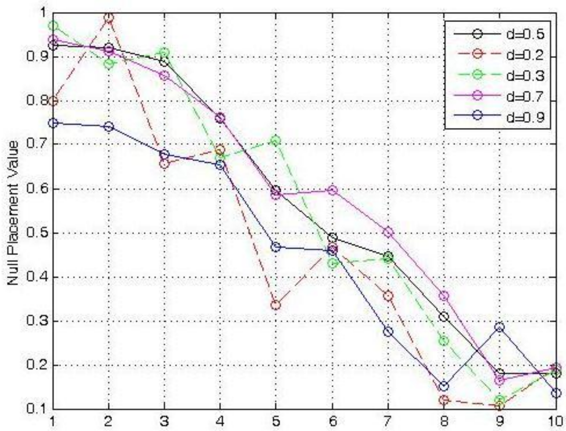

Fig. 10 NULL placement values after optimizing (1) for varying element spaces for d = 0.5, 0.2, 0.3, 0.7, 0.9

Fig. 4-8. shows the different behavior of array factor after optimizing (1) using continuous genetic algorithm resulting the array factor value and max. Sidelobe value.

Fig. 9. shows the value of array factor with respect to the max. Sidelobe level for varying element spaces for d = 0.5,

0.2, 0.3, 0.7, 0.9.

Fig. 10. shows graph for Null placement values received after optimizing the (1) for d = 0.5, 0.2, 0.3, 0.7, 0.9.

VI. Conclusion

As we have seen that array factor depicts very crucial role in formation signal power pattern for smart antenna which is being optimized using continuous genetic algorithm which is robust and efficient for varying element spacing. We have used Continuous GA for optimizing the cost which is very stable and robust for optimizing such problem. So we have worked to get the max value for Sidelobe level and array factor value and finally getting the placement values for placing NULLS while designing the Signal power pattern.

VII. Future Recommendation

There are many fields still needed attention in smart antenna like power consumption, radiation pattern, mean square error equation.

REFERENCES

[1] Widrow, B et al: , Adaptive Antenna Systems, Proceedings IEEE, Vol. 55, No. 12, 1967, pp. 2143-2159.

[2] A. S. Abdallah and F. M. Mousa, “A modified Continuous GA for Smart Antenna System”, journal of Engineering and Applied Sciences 5(4): 332-336, 2010 ISSN: 1816-949X.

[3] Xiaojun Lin, Ness B. Shroff and R. Srikant, “A Tutorial on Cross-Layer Optimization in Wireless Networks”.

[4] R. L. Haupt and Sue Ellen Haupt, Practical Genetic Algorithms, 2nd ed., Wiley, New York, 2004.

[5] Frank B. Gross, “Smart Antennas for Wireless Communications With MATLAB”, McGraw Hills.

[6] R.T. Compton, Jr., “Adaptive Antennas Concepts and Performance”, Englewood Cliffs, NJ: Prentice Hall, 1988.

[7] Muhammad S. Razzaq and Noor M. Khan, “Performance Comparison of Adaptive Beamforming Algorithms for Smart Antenna Systems”, World Applied Sciences Journal 11 (7): 775-785, 2010, ISSN 1818-4952.

[8] Abdallah Khreishah, Chih-Chun Wang, and Ness B. Shroff, “Cross-Layer Optimization for Wireless Multihop Networks with Pairwise Intersession Network Coding”, IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, VOL. 27, NO. 5, JUNE 2009.

[9] Ajit Warrier, Long Le and Injong Rhee, “Cross-layer Optimization Made Practical”.

[10] M. van der Schaar and D. S. Turaga, “Content-Based Cross-layer Packetization and Retransmission Strategies for Wireless Multimedia Transmission”.

[11] L. C. Godara, Smart Antennas, CRC press, 2004.

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