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PERFORMANCE OF MAIN BEAM STEERING AT DIFFERENT ANGLE USING GENETIC ALGORITHM

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ABSTRACT

The demand for wireless communications constantly grows the need arises for better coverage, improved capacity, and higher transmission quality. Thus, a more efficient use of the radio spectrum is required. Smart antenna systems are capable of efficiently utilizing the radio spectrum and promise an effective solution to the present wireless system problems while achieving reliable and robust high speed high-data-rate transmission. Smart antennas dynamically adapt to changing traffic requirements whose adaptive beam forming approach can be studied with the help of different adaptive algorithms.The fundamental idea behind smart antennas is to improve the performance of the wireless communicationsystem by increasing the gain in a chosen direction. This can be achieved by pointing the main lobes of theantenna-beam patterns towards the desired users. Smart antenna system combines multiple antenna elementswith a signal processing capability to automatically optimize its radiation and/or reception pattern in responseto the signal environment. In this paper we analysis of main beam steering at different angle using genetic algorithm.

INTRODUCTION OF GENETIC ALGORITHM

Genetic Algorithms are a family of computational methods inspired by evolution [Holland, 1975; Goldberg, 1986; Goldberg & Holland, 1998]. A genetic algorithm (GA) is a procedure used to find approximate solutions to search problems through techniques such as genetic inheritance, natural selection, mutation, and reproduction (recombination, or crossover). Genetic Algorithms are typically employ using computer simulations in which various problem of optimization is specified. In this problem, array is called individuals and one element of element is called chromosome. The GA consists of an iterative process that evolves a working set of individuals called a population toward an objective function, or fitness function. Traditionally, solutions are represented using fixed length strings, especially binary strings, but alternative encodings have been developed.

A genetic algorithm is a search technique used in computing to find exact or approximate solutions to optimization and search problems. Genetic algorithms are a particular class of evolutionary algorithms (also known as evolutionary computation) that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover (also called recombination). Genetic algorithms are search algorithms based on mechanics of natural selection and natural genetics. In every generation, a new set of artificial creatures or strings is created using bits and pieces of the fittest of the old.

In order to use antenna placement on crowded platforms, there are three methods for synthesizing amplitude and phased array excitations on uniformly arranged antenna element were computer programmed and compared: the numerical method, the analytic method and the Genetic Algorithm method (GA). The comparison of various element was based on how closely the obtained patterns conformed to the desired pattern amplitudes, and on the resulting efficiency of the system. An equation for taper efficiency of a linear array was derived, showing directivity which Greater efficiency would increase gain for a given antenna size. Taper efficiency is useful in evaluating the system performance since different methods can produce very different output of in the form of radiation pattern despite similarity in the resulting patterns. Linear arrays were computer simulated ranging from 5-25 elements. Different excitations, element patterns, and desired pattern here investigated. GA method was programmed to reduce the SLL (side lobe level) and also to steer the main beam at different angle.

The one of the most important parameters in array designing is side lobe level (SLL) and first null beam width (FNBW). In array antenna, the desired value of parameter can be achieved by number of ways such as by having variation in the geometry configuration of antenna, variation in current amplitude or phase feed to the antenna elements.

A. Flow Chart of the approach

The following parameters of Genetic Algorithm decide the performance of optimization.

1. **Crossover** – exchange of genetic material (substrings) denoting rules, structural components, features of a machine learning, search, or optimization problem.
2. **Selection** – the application of the fitness criterion to choose which individuals from population will go on to reproduce**.**
3. **Reproduction** – the propagation of individuals from one generation to the next.
4. **Mutation** – the modification of chromosomes for single individuals

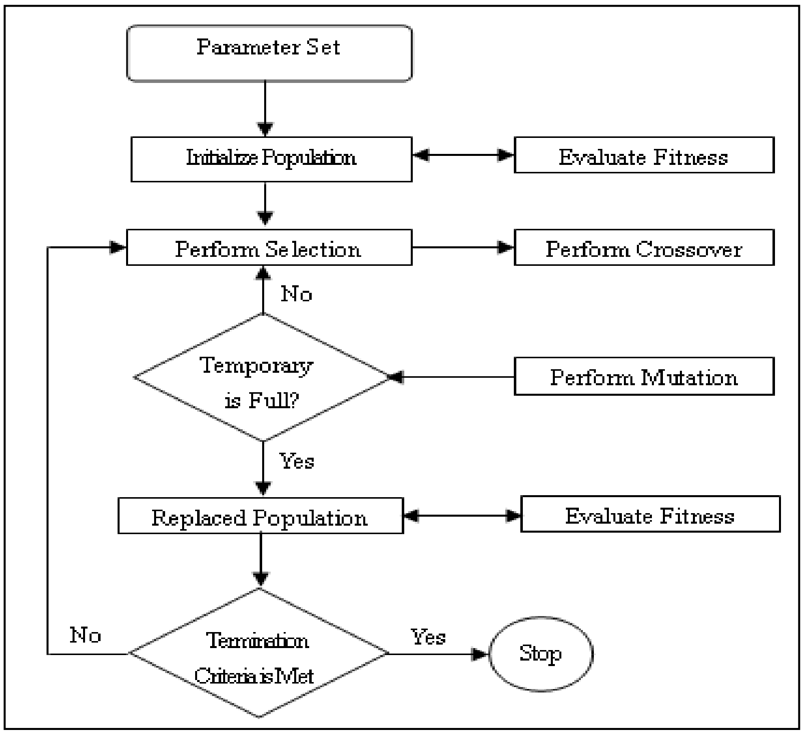

Figure 1: flow diagram of Genetic Algorithm (GA)

B. Smart Antennas for CDMA Cellular Systems

The array antenna comprises of a Uniform Linear Array (ULA) or Uniform Circular Array (UCA) of antenna elements. The individual antenna elements are assumed to be identical, with Omni-directional patterns in the azimuth plane. The signals received at the different antenna elements are multiplied with the complex weights and then summed up. The complex weights are continuously adjusted by the adaptive signal processor which uses all available information such as pilot or training sequences or knowledge of the properties of the signal to calculate the weights. This is done so that the main beam tracks the desired user and/or nulls are placed in the direction of interferers and/or side lobes towards other users are minimized. It should be noted that the term “smart” refers to the whole antenna system and not just the array antenna alone.The following three main blocks can be identified:

1) Array Antenna,
2) Complex Weights and,
3) Adaptive Signal Processor.

C. Modeling of Array Antennas

This section deals with the modeling of the Uniform Linear Array (ULA) and the Uniform Circular Array (UCA) antennas respectively.

C.1 Linear Array

An 8-antenna elements uniform linear array is shown in Figure 2. If the distance between the signal source and the antenna array is bigger than the size of antenna array, it can be considered those signals are in the form of plane waves, each antenna element receives the same amount of energy. However as the wave path is still different, thus the signal phase is different for each array element as well.

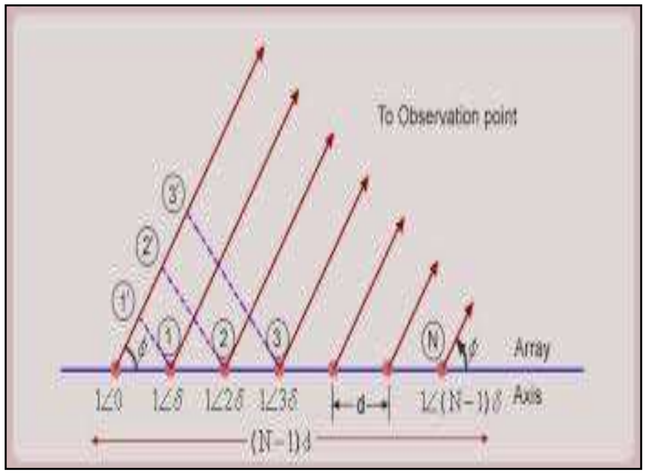

Figure 2: 8-antenna elements linear array

In the above model, using the left element as the setting point, angel of signal direction (the angel of incident signals and normal) is θ distance between element d is half of the wave length λ. As shown in figure 3.8, the wave path difference between known element 1 and reference element is $d\ sin\theta$, phase difference is:

$$\varphi = \frac{2\pi\ d}{\lambda} sin\theta \qquad (1)$$

at time point t, the sum of 8 elements vector is:

$$Y(t) = X_0(t) + X_1(t) + X_3(t) + \ \dots\dots\dots\dots\dots + X_7(t) \qquad (2)$$

$$= X(t) + X(t) + X(t)e^{-j2\pi\frac{d}{\lambda}sin\theta} + X(t)e^{-j2\pi\frac{2d}{\lambda}sin\theta} + X(t)e^{-j2\pi\frac{3d}{\lambda}sin\theta} \dots\dots\dots\dots.. + X(t)e^{-j2\pi\frac{7d}{\lambda}sin\theta}$$

$$Y(t) = \sum_{k=0}^{7} X(t)\, e^{-j2\pi\frac{ld}{\lambda}sin\theta} \qquad (3)$$

Antenna Array Pattern is determined by the followingformula:

$$A(\theta) = \sum_{k=0}^{7} X(t)\, e^{-j2\pi\frac{ld}{\lambda}sin\theta} \qquad (4)$$

C.2 Uniform Linear Array

A ULA consists of antenna elements placed uniformly along a straight line. It is the most commonly used array antenna in mobile communication systems because of its relative simplicity compared to other geometries.

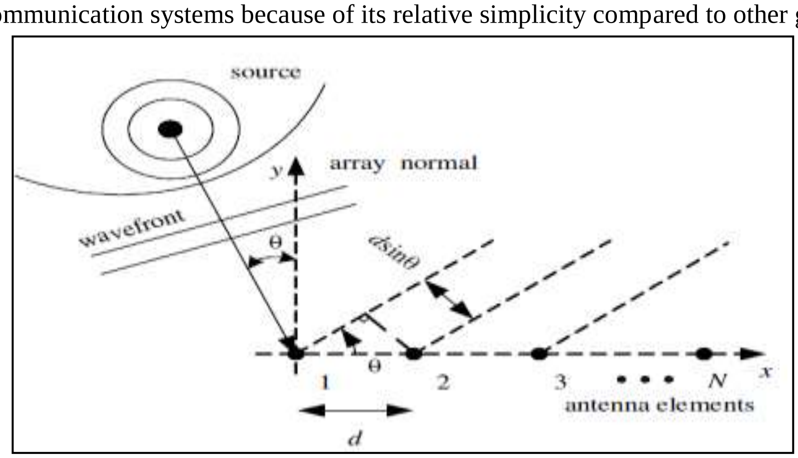

Figure 3: Uniform linear array geometry

Consider a linear array of N antenna elements located at the origin of the Cartesian coordinate system and spaced a uniform distance $d = a/2$ along the x-axis, as shown in figure 3.8. The spatial response of the array due to an incident plane wave from direction is modeled by the N ×1 array steering vector $\boldsymbol{a}(\theta)$. In general, it is the product of antenna
response and the geometrical array factor and is given as:

$$a(\theta) = [U_1(\theta)U_2(\theta)e^{-jkd\sin(\theta)} \dots\dots\dots\dots\dots\dots\dots\dots U_n(\theta)e^{-jk(N-1)\sin(\theta)}]^T \quad (5)$$

Where $K = 2p/l$ is the wave number, $Un(\theta)$ denotes the response of antenna element n and $(\cdot)^T$denotes transpose operation. If mutual coupling between antenna elements is neglected and the individual element patterns are identical, then scaling them with respect to element number 1 reduces to

$$a(\theta) = [1 \ \ e^{-jkd\sin(\theta)} \dots\dots\dots\dots\dots\dots\dots\dots e^{-jkd(N-1)\sin(\theta)}]^T \qquad (6)$$

C.3 Uniform Circular Array

A UCA consists of N antenna elements evenly spaced in a circle of radius R. Consider a UCA of radius R = a/[4sin(π/N)] in the xyplane, as shown in Figure 4. This radius is chosen to maintain an inter-element spacing of d = a/2, equivalent to that used for the linear array. For convenience, the center of the circle is selected as the phase reference.

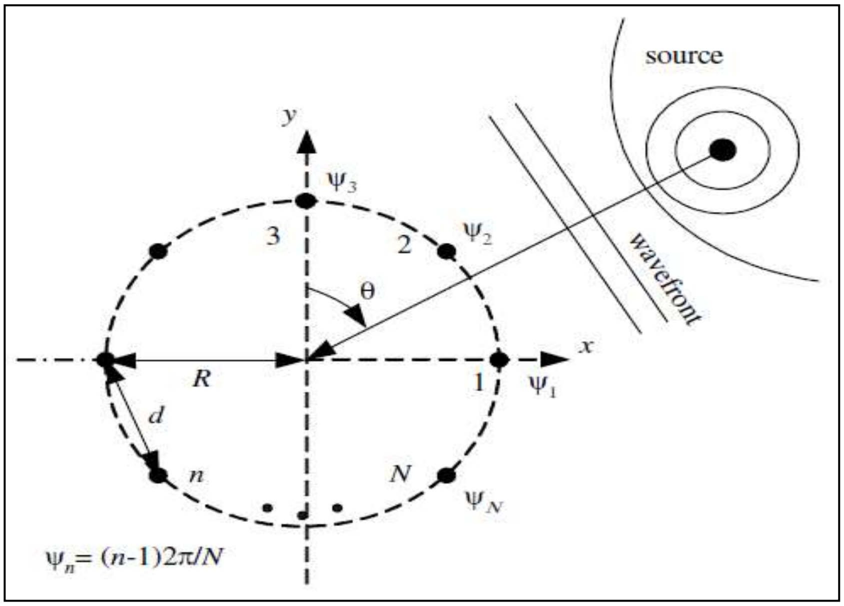

Figure 4: Uniform circular array geometry

Assuming identical and Omni-directional antenna elements, the array steering vector can then be written as.

$$a(\theta) = [\, e^{jkR\sin(\theta+\psi_1)} e^{jkR\sin(\theta+\psi_2)} e^{jkR\sin(\theta+\psi_3)} \dots\dots\dots\dots\dots\dots\dots\dots e^{jkR\sin(\theta+\psi_N)}]^T \qquad (7)$$

Where $\psi_n = 2\pi(n-1)/N$for n = 1, 2, . . . ,$N$is the angular position of the nth element on the xyplane.

Table1: Simulation Parameters

S. No.	**Parameter**	**Description**
1.	Antenna array	Linear antenna array
2.	Optimization method	Genetic Algorithm
3.	Analysis	SLL
4.	Frequency	2.4 GHz-2.9GHz
5.	Element spacing	λ/2

RESULT ANALYSIS OF LINEAR ARRAY FOR SLL REDUCTION AND PHASE STEERING

This section gives the simulation result for SLL reduction and phase steering a different angle by GA technique. The antenna model consists of *N* elements equally spaced with distance of separation $d = 0.5\lambda$ along the *y*-axis. In our investigation, there is an array of 5, 10, 15, 20, 25 elements. After applied the genetic algorithm the side lobe is reduced and main beam is steer at angle 30°, 60°, 90°, 120°, 150°. Various results for different number of element as shown in table .Various result for main beam steering at different angle is given below figure 5,6,7,8 and 9.

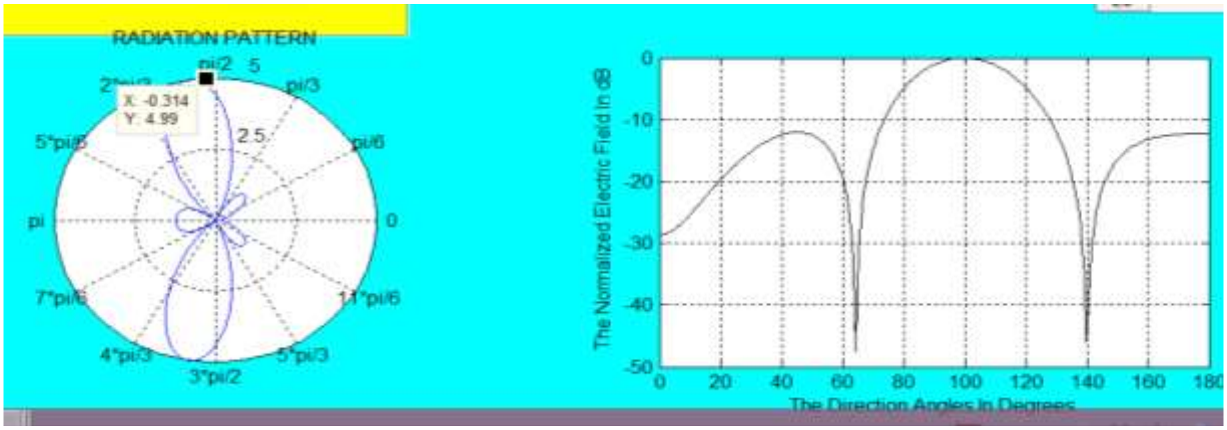

Figure 5: for N=5 main beam steer at 30°

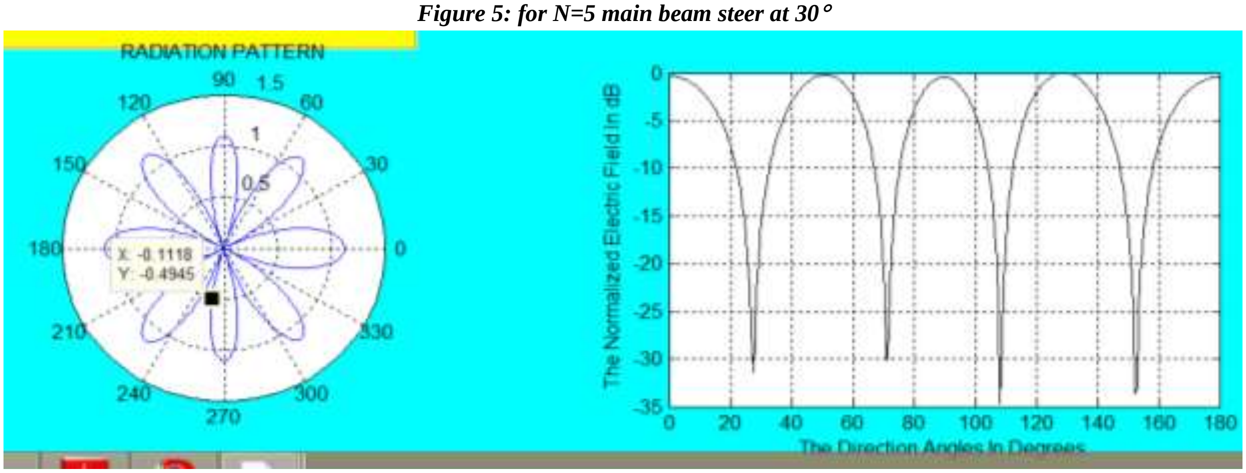

Figure 6:For N=10 main beam steer at 50°

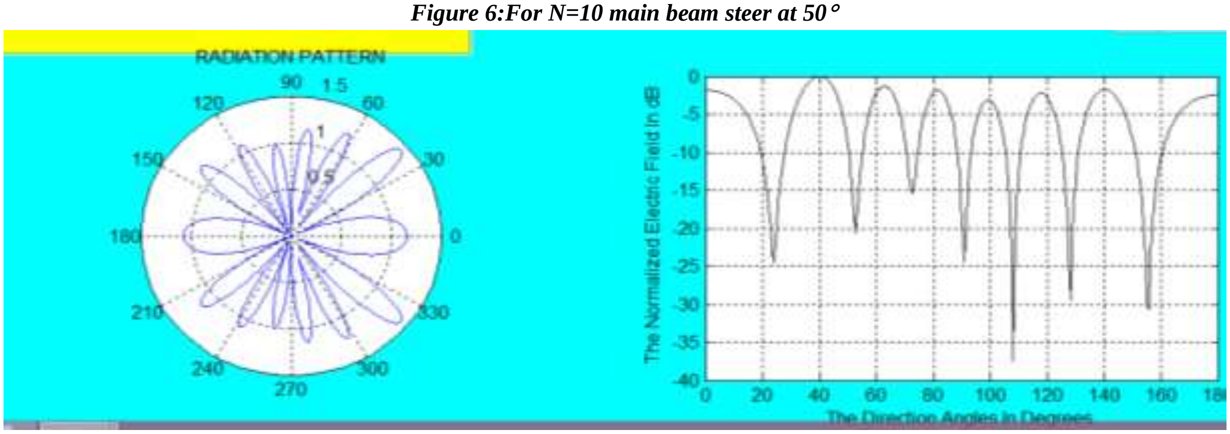

Figure 7: For N=10 main beam steer at angle 40°

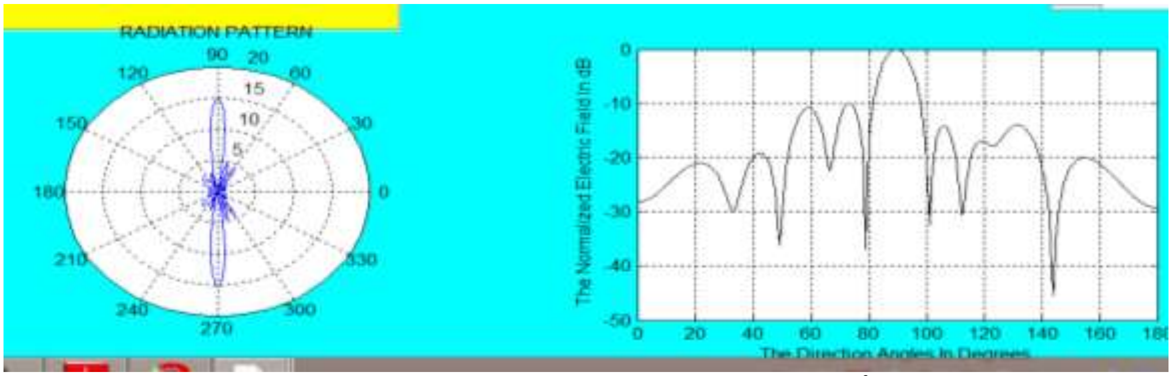

Figure 8: For N=15 main beam steer at angle 90⁰

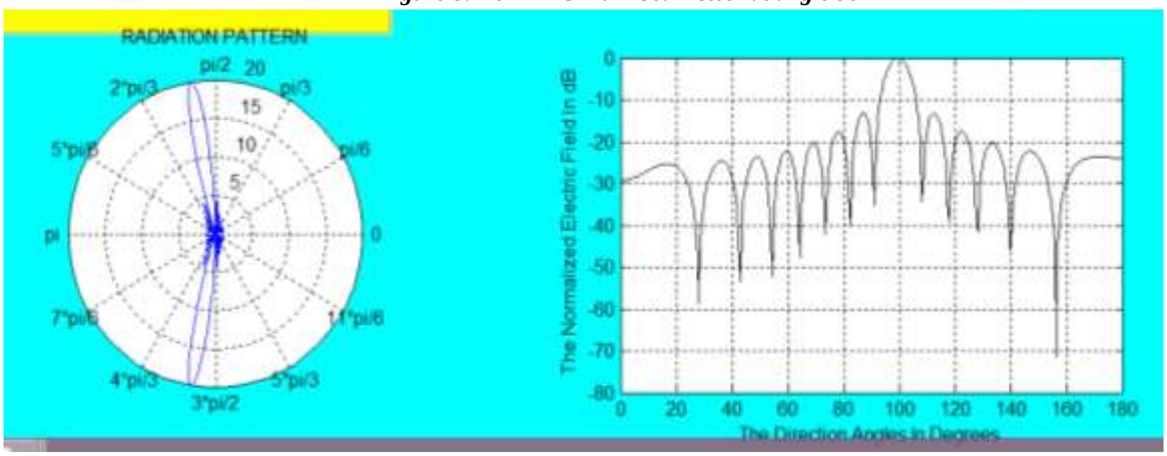

Figure 9: For N=20 main beam steer at angle 110°

CONCLUSION

From the above discussion, after GA applied various simulation results are obtained, it can be clearly seen that for frequency f = 2GHz, spacing between the antenna element is λ/2 , side lobe level is reduced from -13.2233 to -12.0417. In case of N=5, spacing between two element is λ/2, directivity 5.326, the SLL is 0.00068 and main beam steer at angle of 30° for N = 10 spacing between two element is λ/2, directivity 7.0128, the SLL is -0.00193 and main beam steer at angle of 40°. In case of N = 15 spacing between two element is λ/2, directivity 14.9028 SLL is -0.00071, main beam steer at angle of 90°. In case of N = 20 spacing between two element is λ/2, SLL is -0.00537, directivity is 14.0385 and main beam steer at angle 110°.

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