International Journal of Trend in Scientific Research and Development (IJTSRD)
International Open Access Journal | www.ijtsrd.com
ISSN No: 2456 - 6470 | Volume - 2 | Issue – 6 | Sep – Oct 2018

Beamforming for 5G Networks

Irfan Nissar Bhat[1], Er. Harish Dogra[2]
[1]M. Tech Scholar, [2]Assistant Professor
Department of Electronics and Communication Engineering,
Sri Sai College of Engineering & Technology Badhani, Pathankot, Punjab, India

ABSTRACT
In next five years 5G is the most popular and anticipated mobile technology and beam forming is one of the important aspect of 5G networks. Beam forming is a technique used by sensor arrays for a directional signal transmission or reception and is very important for number of applications like Radar, biomedicine, radio communications, SONAR. The paper introduces beam forming technique sand its importance in the modern cellular society

***KEYWORD:** LTE, FRF, ICI, BEAMFORMING, SONAR, ARRAYS.*

I. INTRODUCTION

Beam forming that is also called as spatial filtering, is a technique used by sensor arrays for a directional signal transmission or reception. It can be implemented in many applications like SONAR, RADAR, seismology, biomedicine and radio communications which involves the separating/ spatially locating a required target. Beam forming technique can also be used at either transmitting or receiving ends or it can be used in both ends. This can be visualized as a bulb transmitting light in all directions that is covered by a piece of cloth which has holes on it. So in this, every hole has some quantum light that is coming out of it. Light coming out of these holes can be considered to be different beams. When multiple sensors/ transducers are present next to each other and they emit the light, an interference pattern is seen that is the fundamental point about beam forming. It can be pictured or seen to having many bulbs in a room and when they all emit at the same time, portions of light of one bulb overlaps with the others. Doing now, some small modifications like increasing the distance between each of the bulb, or change the delay of glow for each bulb, the interference pattern obtained can be used for an advantage. In particular, when the bulbs are placed intelligently at an angle, then a greater part of the energy goes out in that angular direction. This reduces the interferences and the required location gets appropriately illuminated. In radio communications, beam forming can be defined as "the combination of radio signals from a set of small Omni directional antennas to give a larger directional antenna". In beam forming technique there are different possible applications with different impacts also in terms of achievable improvements in energy efficiency. The two most common options are namely "per-cell" or reconfigurable beam forming and "per-user" or adaptive beam forming. The main idea behind these two approaches is not only allow addressing beam forming on a "per-cell" or "per-user basis, but also at two different timeframes. The concept of the reconfigurable antenna systems addressed herein allows toad apt antenna parameters to traffic conditions in a timeframe of hours or longer, hence, taking care of the non-uniform spatial traffic distribution by forming appropriate cells. Adaptive beam forming allows to weight antenna elements continuously to form a beam into the direction of interest (a user or a group of users), therefore, improving the spatial filtering within each cell. Hence, the combination of these two techniques with different time granularities will allow to significantly reducing BS power consumption.

II. OPTIMIZATION OF THE BEAM PARAMETERS

It is clear that the output of the antenna array can be controlled with primarily four factors

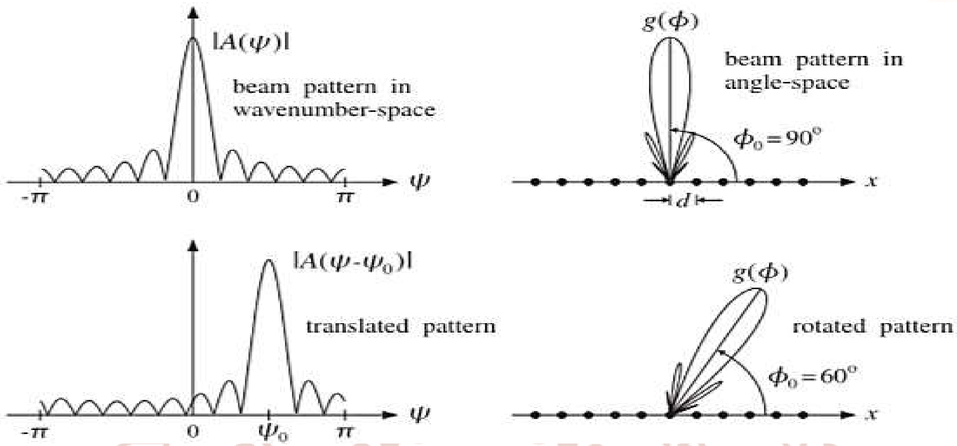
1. Amplitude
2. Phase
3. Number of elements
4. Distance between elements.

The changing of the distance between the arrays elements would be a technically challenging as it requires a special hardware that has to be installed that includes equipment like controller, motors for moving the array elements. For a specific requirement of array factor, the above variables can be modified or optimized over some set of iterations and the required array factor value can be got. In optimization process, there are many algorithms present in the literature. To check all combinations of values of the array, variables are not realistic unless the number of variable is small. Individual optimization of the variables at a time is as good as the gradient vector downhill approach. The steepest descent method which was invented in about the 1800s is extensively used even today and is based on the same concept. While the Hessian Matrix form is used by the Newton's method which uses the second-derivative to find the minimum. Although effective and powerful than steepest method, the main drawback that is about the newt on method is the cost function. For this reason, in 1965, Nelder and Mead thought away from the derivatives and introduced the downhill simplex method. It's stability in the approach has attracted many powerful computing software like MATLAB to make it an integral part of its packages. A simplex contains n + 1 sides in an n-dimensional space. A new vertex of the simplex is generated for every it eration; Updating of the vertex with better values is done. Over a finite number of iterations, the simplex value gets small and accurate. In the 1960s methods like Successive Line minimization were brought into force. The algorithm chooses a random point and proceeds in a pre-set method until the cost function increases. Once an increase is encountered, the algorithm starts with a new direction. Here the conjugate direction does not interfere with the minimization of the prior direction. Powell then proposed a method by which changes to the gradient of the cost function remains perpendicular to the previous conjugate directions. The BFGS algorithm again considers the Hessian matrix (Matrix obtained from the second derivatives) for calculation of the next search point. As this method uses the similar concept of Newton's method it's also called as "Quasi Newton" method, though the hessian matrix that is used is not the same. The next type is where the cost function is assumed to be quadratic and the other constraints are linear. It is built on the basis of Lagrange Multipliers which again require the derivatives or approximation principles. This type is called as the Quadratic Programming.

For desired patterns with combinations of weights, tapers, non- uniform element spacing numerical optimization is one widely adopted method. A few examples of non-uniform synthesis are Nelder Mead downhill simplex algorithm, steepest descent, simulated annealing and dynamic programming. These methods used side lobe levels with constraints and other parameters in order to shape better the main beam. For finding the phase tapering that exploited the array directivity numerical optimization was incorporated, and to find the optimum phase tapering to diminish side lobe levels, the steepest descent algorithm was used. The characteristic of an antenna array that are to be minimized is returned by the cost function that is associated with it. For example, in the case of a 6 element array to find the minimum and maximum side lobe level by varying the amplitude and phase weights that lies along the x axis. The parameters like elements spacing, amplitude and phase weights are symmetric with respect to centre of the array. Therefore, the specification for one half of the array should be sufficient. For the conception of cost surface, two variables will suffice. They can be any combination of amplitude, phase and distance between the elements. But a point to be noticed is that, these are local optimizations and don't offer good efficiency as the start is in a random point. For this reason, global optimizations like Simulated Annealing or Genetic Algorithms. The gist of genetic algorithm is given below. The genetic algorithm begins with a random set of configurations (the matrix rows called as population) which consist of the variables such as element spacing, phase and amplitude. Every such configuration is assessed by the cost function that returns a value like maximum side lobe level. The configurations can have binary or continuous values. The high cost configurations are discarded while low costs are placed in the mating pool. From the formed pool, two parents are randomly selected and the selection is such that it is inversely proportional to the cost. As a result of the combination of parents, offspring is formed. These newly offspring replaces the array configurations that were discarded. This process continues for all the population, mutated or modified randomly. This finally gives a new array configuration and their costs are evaluated. Based on the application requirements of efficient power consumption or better user directivity, the required format of steering or weighting can be used and the required level of optimisation can be incorporated for any the applications.

III. BEAM STEERING

Before elaborating on multi-beam in depth, first consider the case of only steering the beam to the required direction of the user. This is because, the multi-beam has one of its input parameters are the desired angle, for which the understanding of beam steering is essential. The steering of a beam to the desired users will help in better locating the users and thereby aiding in the smoother casting of the beam. At the same time, to reduce the power radiation in the undesired direction.

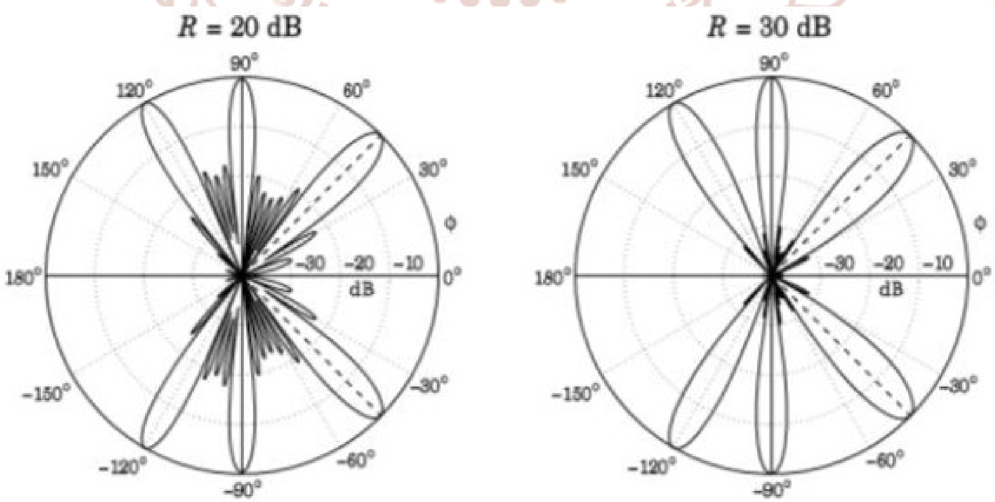


Beam Steering

IV. MULTI-BEAM BEAM FORMING

Moving on to multi beam beam forming with arrays, As explained, it is used to cast the beams with a certain amplitude and in a certain direction. The following code does the multi beam beam forming.

```
w=taylor1p(0.5,90,21,30);                    % unsteered weights
a=multibeam(0.5,w,[1,1,1],[45,90,120]); %equal-amplitude beams
[g,ph]=array(d,a,400);                        % compute gain
dbz(ph,g);                                    % plot gain in dB
addray(45); addray(-45);                      % add ± 45° grid rays
```



Multi beam beam forming with Relative Side lobe level at 20 dB and 30 dB respectively

The above the multi beams for amplitudes of 1, angles as 45^o, 90^o, and 120^o respectively. Now, there are 2 cases above, the relative side lobe level R of 20 dB and 30 dB.

V. CONCLUSION

This paper presents a very novel way of utilization of robustness of beam forming techniques in 5g networks. The array consists of multiple signal beams which in turn pave way for smart and lossless directional transmission, thus enabling better communications in fields like navy and de fense and aerospace etc. The equipment's like sonar, radar etc. get to be used to their smartest capabilities in turn yielding efficient and accurate results.

REFERENCES:

1. Ali Sahlli, Nordin, Mahamod Ismail, FadzilahAbdulah "Beam forming techniques for massive MIMO systems in 5G: overview, classification and trends for future research" 2017, Frontiers of Information Technology and Electronic Engineering, DOI: 10.1631/FITEE.1601817.
2. G. Charis. N. Showme "Beam forming in Wireless Communication Standards: A Survey" 2017, Indian Journal of Science and Technology, Vol 10(5), DOI: 10.17485/ijst/2017/v10i5/99018
3. Shoriful Islam, KartickMondal, TazkiaJessy "Suitable Beam forming Technique for 5G Wireless Communications" 2016, Research Gate.
4. Abdoulaye Tall, Zwi Altman, Eitan Altman "Multilevel beam forming for high data rate communication in 5G networks" 2015, arXiv: 1504.00280v2 [cs. IT].
5. WoonHau Chin, Zhong Fan, Russell Haines "Emerging Technologies and Research Challenges for 5G Wireless Networks"
6. ZoranBojkovic, MiodragBakmaz, BojanBakmaz "On the Road to Energy Efficient 5G Mobile Networks" Recent Advances on Systems, Signals, Control, Communications and Computers.
7. Arunitha, A., Gunasegaram, T., Kumar, N.S., et al., 2015. Adaptive beam forming algorithms for MIMO antenna. Int. J. Innov. Technol. Explor. Eng., 14(8):9-12.
8. Wieland, "mobileworldlive.com," GSMA, 8 May 2014. [Online]. Available: http://www.mobileworldlive.com/. [Accessed 8 May 2014].
9. Wikipedia," Wikipedia, 12 January 2014. [Online]. Available http://en.wikipedia. Org/wiki/Directivity. [Accessed 2 May 2014].
10. T. Haynes, A primer on Digital Beam forming, 1998.
11. D. G. V. Tcheslavski, "ee.lamur.edu," 2008. [Online]. Available:ee.lamar.edu/gleb/em/Lecture%2010%20-%20Antennas.ppt.
12. "Jordan University of Science and Technology," 02 Feb 2007. [Online]. Available: www.just.edu.jo/~khodier/EE%20700/antennas.pdf. [Accessed 10 Feb. 2014].
13. S. J. Or fanidis, Electromagnetic Waves and Antennas, 1999-2010.
14. T. Goncalves, T. U. o. L. L. P. IST, L. Correia and F. Cardoso, "Energy efficiency using beam forming at the base station in UMTS and LTE," in Software, Telecommunications and Computer Networks (Soft COM), 2012 20th International Conference on, Split, 2012.