Bandwidth and Radiation Management of GSM System using Neural Networks

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ABSTRACT
Bandwidth and the radiation pattern of an antenna play a crucial role in long as well as short distance communication. Nowadays, the increasing population and the unequal use of communication channels are making it difficult to manage the bandwidth of a communication system. Also, the radiation of the antenna is inefficiently used in many areas. One of the solutions to these problems is using neural networks. It will help in easier management of the overall network parameters. The allocation of bandwidth and the control of radiation pattern will become extremely simple. All the factors will be automatically updated according to the existing requirements thus, making the system a self-learning system.

Keywords
Neural Network, Bandwidth, Radiation, Directivity, linear neural networks.

1. INTRODUCTION
Since the advent of the communication age, antennas have become an integral part of development of any type of communication system. Any system, whether used for communicating long or short distances, has to use specific types of antennas. Hence, the parameters of antennas have a substantial effect on the designing of systems. Some parameters such as the bandwidth and the effective radiation have a great influence on the efficient working of the system. Hence, these parameters have to be used as effectively as possible.

But due to the ever increasing demands of the ever increasing population of the world, there is a lot of strain on the existing resources. This strain is especially on the infrastructure of the developing countries. Hence, something has to be done to use the existing resources as efficiently as possible. Here, as there is unequal distribution of population in developing countries, there are a lot of problems in setting up areas where the bandwidth of the antennas can be effectively used. In many urban areas the number of users using these communication devices is much more than in the rural areas. Hence, the bandwidth of the antenna is severely affected and also a lot of radiation power has to be maintained whilst, in rural areas the number of users is comparatively less and hence larger bandwidth is not required.

Artificial Neural Networks is basically a network which can be trained to produce certain outputs based on certain given inputs. But, here it is a different case. In normal digital as well as analog networks, the overall functioning of the network is pre-decided based on the inputs to be given and the outputs to be produced based on those inputs. In Artificial Neural Networks, the neurons which are present in the network are trained by setting the inputs and the target value. The Network has to be trained several times before implementing it so that the error, which is nothing but the difference between the output obtained by the network and the target output, can be reduced.

The error in these kinds of networks can be reduced by changing the weights and the bias of the networks. These weights and bias applied to the network do not have to be changed manually. These parameters are changed by the network itself and by changing these parameters, the network tries to reduce the difference between the output which is obtained and target output. The advantages of neural networks are the autonomy it provides. It means that the network will change and manage the network by itself and very less external help is required by the network after it has been trained. Also, many logical conditions and mathematical equations can be realized by using neural networks. The same if done by using normal systems and simple circuits are very difficult to realize.

2. PROJECT DESCRIPTION
In a GSM Network, the multiplexing is done in two ways. It is TDM [Time Division Multiplexing] and FDM [Frequency Division Multiplexing]. This means that the channels in GSM are divided in frequency as well as time. This is done with a sole purpose of efficiently using the bandwidth provided.

But, at the same time, the bandwidth required by each area and the amount of time slots required in each channel can vary depending on the magnitude of the users in that area. If supposedly the number of users in an area A is less and still the bandwidth provided to them is same as that of the bandwidth provided to more number of users in some other area B, then the bandwidth in area A is unused while that in area B is strained as the channel capacity in area B will be lower than the required information rate.

If a particular base station region is such that there are irregularities in the use of its radiation. It means that in some areas of that cell there is a lot of use of the radiation as the number of users is high or the radiation cannot penetrate to longer distances because of losses due to obstacles, then the radiation pattern or the radiation power has to be changed accordingly so that maximum radiation can be used with minimum power wastage.

Now, all the above examples show that controlling the bandwidth and the radiation is very important for efficient communication in areas where the population density is high and its distribution is unequal. These problems mentioned above can be easily controlled and a system can be designed using Neural Networks.

3. OUTLINE FOR THE NETWORK

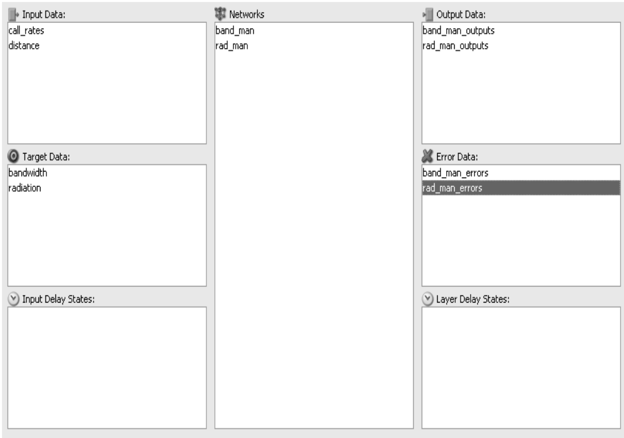

Fig. 1 Neural Network tool window

Here, at first, there will be sensors applied to the base station which will sense the number of users in a given area. Then, the call rates of the areas will be obtained. If the call rates of the area are above a certain limit, the sensors will provide a high '1' as the output. The threshold will be decided based on the overall population of the area and the call rates of the population of that area. Now, the outputs of these sensors will be given as input to the neural network. Another part will be the radiation management. Here, the sensors will be collecting the information about the distance of the users from the base station. Here, the sensor system will sense not only the number of users, but also the distance of those users from the base station. The sensors will then give an output of high'1' if the amount of users and the distance of those users from the base station increase above a certain limit.

We used Matlab to train and execute the neural network. In, Matlab, the 'nntool' function as used which provides a direct platform where one can select different types of networks, train them by providing inputs, target values and different weights and bias values, and finally simulate these networks for different values of inputs. As, there was already a platform for training the network, we did not have to provide any kind of code to train and simulate the network.

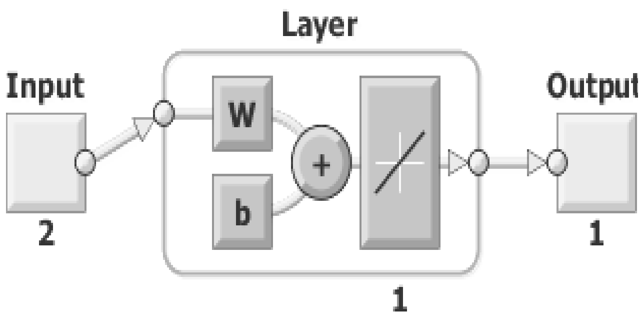

Fig. 2 Single Layer Linear Network

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[0 0 1 1;
 0 1 0 1]
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Fig. 3 Inputs given to the network

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[0 1 -1 0]
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Fig. 4 Target set for the network

The above two figures show the inputs which we have taken for our network. The second figure shows the target output required for the various input conditions.

In our Neural Network tool, we used a Single Layer Linear Network and then used different cases for the two inputs; one for Area A and one for Area B. The network used is shown in the above figure. Then we provided target values for each case of the two inputs. Providing these input and target values for the network, we trained the network continuously for two to three times till the error of the network was completely zero for all the cases. The weights and the bias were initially set to zero. After training the network, the weights changed to 1 and -1, but the bias remained the same. The formula which is being used to train the network and change the weights is:

w*i*(new)=**w***i*(old)+**x***i****y**

b(new)=**b**(old)+**y**

4. PERFORMANCE

The performance of the neural network is as shown in the figure below. It shows the performance of the system after 2000 iterations or epochs. The performance of the network shows that after 1000 epochs, the error of the system is reduced to 0. We tried it with 10 as well as 100 iterations, but then the network had to be trained aroung 10 to 15 times minimum to get a close output. For 10 iterations, around 100 training periods will be needed.

The performance parameters show that the error decreases as we continue to train the network. The error is present as the weights and the bias values for the inputs and the network are taken randomly. The error decreases as we train the network. In training, the weights and the bias value change which causes the overall system parameters and thus the system performance to change.

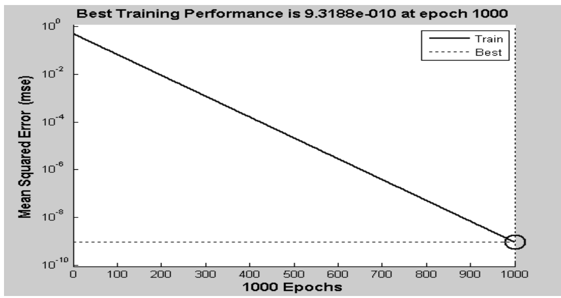

Fig. 5 Performance of the network after first training

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[0 0.99996 -0.99996 0]
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Fig. 6 Output of the network after first training

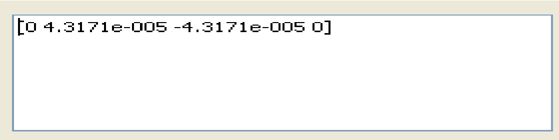

Fig. 7 Error of the network after first training

The output above should have been as shown in the table below. But, the value of 1 and -1 consist of errors. The errors shown in the above second figure. Hence, the network has to be trained again so that the eror is reduced.

In the graph shown below, the best training performance is obtained at 1000th epoch. It is actually the 2000th epoch as the graph shows the 2nd training. The error is reduced to a great extent and the output obtained is equal to the target which we set. The output should come out to be as follows:

Call Rates in Area A	Call Rates in Area B	Bandwidth change in area
0	0	0
0	1	1
1	0	-1
1	1	0

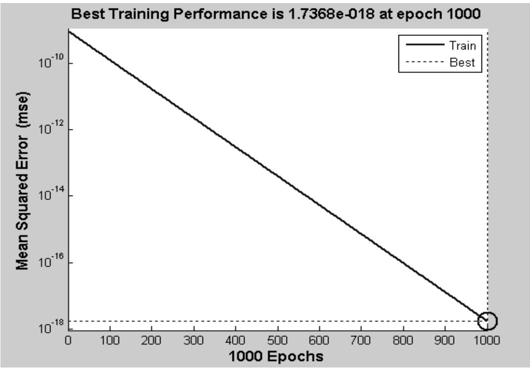

Fig. 8 Performance of the network after second training

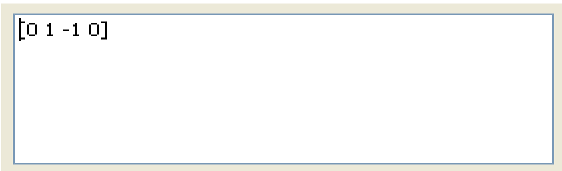

Fig. 9 Output of the network after second training

The above figure shows the output which is obtained after training the network for a second time. Hence, the output obtained is equal to the target output which was required of the system. The error value after training the network for a second time is as shown below.

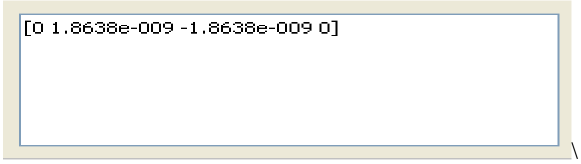

Fig. 9 Error of the network after second training

Here, we only have shown the iterations an performance of the system related to bandwidth management. We have not shown the performance parameters related to radiation management. It is because; the performance of the radiation management system will be totally same. The overall parameters such as the target, inputs, the errors obtained and the output obtained after training will be same for radiation management.

5. CONCLUSION

Thus, it is seen that GSM system can be easily managed, controlled and its efficiency can be increased using neural networks. We have seen that the system becomes extremely flexible by just using a simple linear neural network. So, if linear neural networks are used for all the factors of the system or even the factors that have a major effect on the system, then the system becomes a auto-learning system and it becomes very easy to manage it which directly and indirectly saves a lot of time and cost. Also, by introducing neural networks, one can easily make the system which can adapt to any given situation. These situations will not require any human assistance and will be completely automated.

Lastly, factors like the movement of the users, the importance of the information or the security of the information which is being carried around is not being concerned with in this paper. If these factors are also considered then it will make the system more efficient, flexible and secure.

6. ACKNOWLEDGMENT

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7. REFERENCES

[1] Theodore S. Rappaport, Wireless Communications: Principles and Practice, 2nd Edition, Pearson.

[2] McCulloch, Warren; Walter Pitts (1943). "A Logical Calculus of Ideas Immanent in Nervous Activity". *Bulletin of Mathematical Biophysics* **5** (4): 115–133. doi:10.1007/BF02478259.

[3] “Introduction to Neural Networks for Intelligent Control” by Behnam Bavarian.

[4] “A Neural Network Routing to Multicast Routing in Real-Time Communication Networks” by Chotipat Pornavalai, Goutam Chakraborthy and Noroi Shiratori.

[5] Mathworks website for NN Toolbox webinar.