Optimization of QoS Parameters for Channel Allocation in Cellular Networks Using Soft Computing Techniques

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Abstract. The usage of mobile communications systems has grown exponentially. But the bandwidth available for mobile communications is finite. Hence there is a desperate attempt to optimize the channel assignment schemes. In this work, some of the quality of service parameters such as residual bandwidth, number of users, duration of calls, frequency of calls and priority are considered. Genetic Algorithm and Artificial Neural Networks is used to determine the optimal channel assignment considering the quality of service parameters. The simulation results show that Genetic Algorithm performs better than Heuristic Method. But application of Artificial Neural Networks outperforms Genetic Algorithm and Heuristic method by a considerable margin. Channel allocation can be optimized using these soft computing techniques resulting in better throughput.

Keywords: Genetic Algorithm, Channel Allocation, Quality of Service, Artificial Neural Network, Throughput.

1 Introduction

The evolution of Mobile Communication System has been rapid. The number of cell phones has exceeded the number of PSTN phones globally. But unfortunately the wireless bandwidth available for mobile communication is fixed and cannot be increased. Thus making optimization of channel assignment schemes an important area of research in the wireless community.

A very successful technology in the Mobile Communication Systems is Global System for Mobile Communication (GSM). GSM divides geographical regions into cells. The adjacent cells cannot use the same frequency at the same time which would result in interference and low quality of service. There has been considerable amount of research literature into channel assignment [1,4,5,10] schemes sharing the frequencies among cells minimizing interference. Not many literatures exist which concentrates on quality of service parameters like available residual

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bandwidth, Number of Users in a cell, Periodicity of calls, Priority of calls, time of call and frequency of calls. In this paper, these Quality of Service parameters are taken into account. Genetic Algorithm and Artificial Neural Networks is applied to these parameters to optimize the channel assignment.

1.1 Introduction to Genetic Algorithms

Genetic Algorithms[8,9] are heuristic adaptive search algorithm based of the evolutionary idea of natural selection and genetic, used to simulate processes in natural system necessary for evolution. Introduced by John Holland in 1960, Genetic Algorithms can be applied in many fields in engineering.

The operations of Genetic Algorithms are simple such as, copying of strings, swapping partial strings, etc. The parameters are represented as strings of bits. Initial population is created randomly and subjected to the fitness function for evaluation. A simple set of operations is performed on the initial population to generate successive population which closes towards optimized results.

The simple set of operations performed in Genetic Algorithm is:

Reproduction : is a process of selecting strings with better fitness value compared to strings with lower fitness value for the next generation. Selecting an individual string according to its fitness value leads to a higher probability of it contributing a better offspring in the next generation.

Crossover : is a process of exchanging information among strings selected during reproduction. The set of individuals are selected at random and mated. Mating is the process of selecting a position called crossover point, within the length of the string and exchanging the bits between the two strings. Crossover together with reproduction gives optimized results with recombination of individuals.

Mutation : is the process of changing a single bit information of the string. Mutation takes place rarely at the rate of one in one thousand reproductions. It reflects the biological mutation taking place over a long period of time.

1.2 Introduction to Artificial Neural Networks

Artificial Neural Network (ANN)[2,3,6,7] is similar to biological neural network in its structure and some features. Artificial neural network is mainly used in optimization problems, it may be either minimization or maximization problem. ANNs are implemented on computers. The capabilities of an ANN involve

- Processing of Parallel operations
- Flexibility in adjustment of the system weights while training the system so that the ANN can be adjusted to the new environment.

Structure of ANN:

The ANN is composed of an input unit, processing unit and an output unit. All units are interconnected according to some topologies such as bidirectional, auto associative, group of instar, group of outstar, etc. The processing unit performs

summing operations & updating weights based on the desired output. The input and output units may be continuous, discrete, deterministic or stochastic.

The structure of ANN consists of interconnected processing unit [5] as shown in Fig.1 which contains Summation Unit. The output of the summation part is calculated based upon the given input values (may be continuous or discrete data) and the weights (either positive or negative) assigned to those input units. The computed value (weighted sum) is called as the activation value. The output unit (continuous or discrete) produces a signal from the activation value. The weights in the network are adjusted in order to store the output pattern in a network. The process of adjusting the weights is known as learning. The learning law or algorithm follows the procedure for updating each of its weights. Learning can be performed either as supervised or as an unsupervised manner.

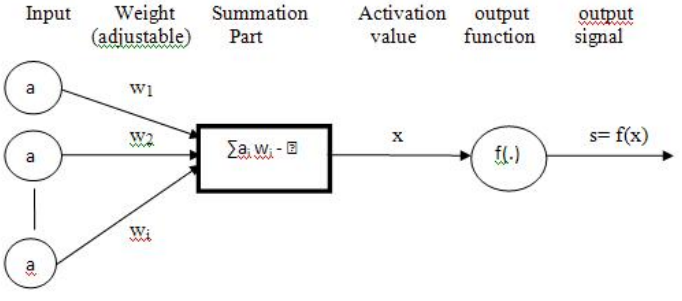

Fig. 1. Basic Model of ANN

$$\text{Activation value } (x) = \sum_{i=1}^{M} a_i w_i - \theta \tag{1}$$

Where a_i is set of inputs, w_i is set of weights and θ is bias term

$$\text{Output signal } (s) = f(x) \text{ [output function]} \tag{2}$$

Learning requirements

The requirements of learning laws[2] are given below

- Learning leads to convergence of weights.
- Learning time should be small (for capturing the pattern information from samples)
- Learning uses only local information (change in the weight on a connecting link between 2 units depends on the states of these 2 units only). Due to this, learning can be done in parallel. Hence it speeds up the learning process.
- All possible patterns in the network should be captured by learning.

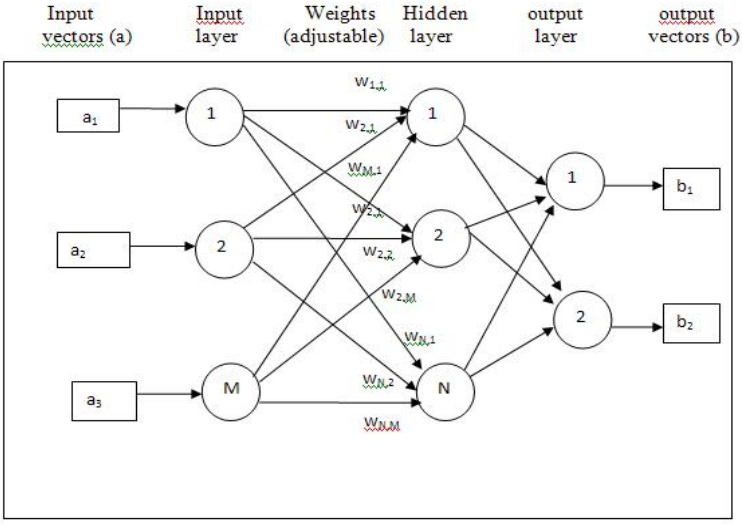

Fig. 2. Basic Feedforward Neural Network

2 Proposed Scheme

There are two distinct classifications of channel allocation schemes called as Fixed Channel Allocation and Dynamic Channel Allocation. Frequency allocation is static in fixed channel allocation. But the dynamically selected channel minimizes interference in dynamic channel allocation. Whenever there are call requests and lesser number of channels free for assignment to all requests, some of the quality of service parameters must be considered to decide on who should be allotted the channel. The quality of service parameters such as duration of calls, number of users, residual bandwidth, priority of calls, time of call and frequency of calls which can be considered for decision making of channel allocation. Genetic Algorithm, heuristic method and Artificial Neural Network is applied to these parameters for optimal allocation.

2.1 Quality of Service Parameters Considered for the Proposed Problem

Duration of Calls(a) : Parameter 'a' is referred to as the duration of a call by a user. If there are a number of call requests, the call with maximum duration must be given priority so that it yields maximum profit to the service providers. The range of call times is obtained using recorded history of usage by users over a period of time to find the average range of time that users hold the channel allocated to them.

Number of Users(b) : The number of Users is a cell making a call request is another important parameter affecting the quality of service. If the number of users is less than the number of available channels, then the call request can be

granted without affecting service of others. But when the number of users are more than the channels available, it would lead to forced termination of some calls, hence affecting the quality of service.

Residual Bandwidth(c) : Residual Bandwidth or the number of free channels available in a cell is another Quality of Service parameter which can affect the service quality.

Priority of calls (d) : depending upon whether it is a handoff request or a new call request, the priority parameter can be set. The handoff call must be given the highest priority to avoid disconnection of ongoing connection.

Time of Call (e) : Time of the day can be classified into number of slots and assign different priorities to each slot.

Periodicity(f) : Periodicity is defined as the frequency of calls by a user. If the frequency of calls from a user is high, then denying a call request will not affect as much as denying a call request from an infrequent user.

3 Application of Genetic Algorithm

In order to apply genetic algorithm to the problem, The parameters have to be encoded to strings. The parameters are represented as eight bit strings. Some of the parameter values are obtained from the history of the caller. The time duration of a call by a user is represented by Parameter 'a', with 10 seconds assumed as one unit. A value of a = 5, would imply the periodicity of the call to be 50 seconds. The parameter priority is higher if the value of d is higher. Hence if d = 100, then it has a higher priority than $d_2 = 65$, but lesser than $d_3 = 150$. Depending upon the density of users in a cell, a unit is selected like 10 users as one unit. Hence a value of b=45 would indicate 450 users. A fitness function is needed and initial population as seed is required. The fitness function is given by,

$$F(X) = a + 1/b + c + d + e + 1/f \qquad (3)$$

The fitness function for this application is a maximization function. The seed values are randomly generated and tabulated as shown in table below.

4 Application of Artificial Neural Network

Radio spectrum is limited in wireless communication systems. Therefore the system capacity is improved by means of effective use of available channels. The channel allocation problem [3,4,5] is used to allocate channels by means of minimizing the probabilities of call blocking or dropping and by maximizing the quality of service. So the channel allocation problem is an optimization problem also Np- hard. Hence it uses neural network for solving the problem.

The feedforward neural network as shown in Fig. 2 is used for optimized channel allocation problem proposed in this paper. The assignment of channel is based on the output units of neural network.

Table 1. Randomly Generated Seed Sample

Sl. No	Duration of call(a)	Number of Users(b)	Residual Bandwidth(c)	Priority(d)	Time of call(e)	Periodicity(f)	F(x)
1	225.0	18.0	228.0	226.0	255.0	255.0	934.06
2	251.0	10.0	199.0	248.0	255.0	255.0	953.10
3	252.0	110.0	225.0	248.0	255.0	255.0	980.013
4	70	62	9	34	133	27	246.05
5	121	195	203	90	226	62	640.02
6	20	155	167	182	178	55	547.02
7	78	203	75	185	184	53	522.02
8	138	136	37	160	244	186	579.01
9	189	161	76	214	108	158	587.01
10	56	241	58	70	102	51	286.02
11	107	147	82	16	151	207	356.01
12	36	41	190	72	146	149	444.03
13	136	96	217	125	66	161	544.02
14	74	4	19	206	242	84	541.26
15	199	14	104	151	20	143	474.08
16	103	159	244	221	148	249	716.01
17	92	73	94	165	239	153	590.02
18	50	43	16	172	18	214	256.03
19	193	111	223	85	60	9	561.12
20	238	216	73	251	39	83	601.01

The input unit contain 6 parameters for the proposed method. Parameters 'a', 'c', 'd', 'e' are directly proportional and 'b' and 'f' are inversely proportional to the output. The probability of the usage per day indicates weight in the network. The unsupervised learning method is adopted in the proposed method. The method uses Instar (Winner take all) learning law [6,7] which is unsupervised learning process. Here the initial weight assigned to the network is random prior to learning and vectors are normalized during learning. In Instar learning method, all the inputs are connected to each of its output layer (1, 2 … N) in a feedforward manner. The summing part has to be calculated using input vector $a = (a_1, a_2, \ldots a_M)$ and weights ($w_{i,j}$ indicates weight assigned in the link connecting i^{th} output node with j^{th} input node).

The output for each unit i is computed as $w_i^T a$. The maximum output of the unit (k) is found out by using

$$w_k^T a = \max (w_i^T a) \tag{4}$$

The weight vector is adjusted to the k^{th} unit as follows

$$\Delta w_k = \eta (a - w_k) \tag{5}$$

where η is learning rate parameter (that affects the convergence speed and stability of the weights during learning)

$$\Delta w_{kj} = \eta (a_j - w_{kj}) \quad \text{for } j = 1 \text{ to } M \tag{6}$$

The error measure depends on the parameter. If there is any change in the parameter then that affects the error measure. Hence there exists a inter relationship between parameter and error measure.

Table 2. Input vector (10 different set of values generated randomly from 1 to 255 for 6 input parameters)

a	70	121	20	78	138	189	56	107	36	136
(1/b)	0.0161	0.0051	0.0064	0.0049	0.0073	0.0062	0.0041	0.0068	0.0243	0.0104
c	9	203	167	75	37	76	58	82	190	217
d	34	90	182	185	160	214	70	16	72	125
e	133	226	178	184	244	108	102	151	146	66
(1/f)	0.0370	0.0161	0.0182	0.0189	0.0053	0.0063	0.0196	0.0048	0.0067	0.0062

Table 3. Six Different Weights considered

wi \ j	1	2	3	4	5	6
w1	0.1	0.1	0.2	0.3	0.1	0.2
w2	0.3	0.1	0.1	0.15	0.25	0.1
w3	0.241	0.123	0.248	0.176	0.058	0.154
w4	0.2	0.3	0.1	0.2	0.1	0.1
w5	0.345	0.124	0.045	0.164	0.151	0.171

Table 4. Activation Value for ten different set of Inputs

a	70	121	20	78	138	189	56	107	36	136
(1/b)	0.0161	0.0051	0.0065	0.004926	0.007353	0.006211	0.004149	0.0068	0.0244	0.0104
c	9	203	167	75	37	76	58	82	190	217
d	34	90	182	185	160	214	70	16	72	125
e	133	226	178	184	244	108	102	151	146	66
(1/f)	0.0370	0.0161	0.0182	0.018868	0.0053	0.006329	0.019608	0.0048	0.0067	0.0062
X (for w1)	32.3090	102.3037	107.8043	96.70427	93.6018	109.1019	48.40434	47.0016	77.8038	101.1023
X (for w2)	60.2553	126.6021	94.5024	104.6524	130.1013	123.4013	58.60238	80.4511	77.1031	97.7516
X (for w3)	32.8077	108.4561	88.5956	80.63351	84.7477	108.3267	46.11953	57.6985	76.9400	112.4222
X (for w4)	35.0085	85.1031	74.9037	78.50336	87.7027	99.0025	41.20321	47.9025	55.2079	80.5037
X (for w5)	50.2223	99.7694	71.1449	88.41284	112.3608	120.0309	48.81587	66.0317	54.8281	87.1533

5 Performance Analysis with Heuristic Method,Genetic Algorithm and Neural Networks

Testing the performance of the system was done using Matlab. For each case study, any two parameters are constantly increased at a predetermined interval and the performance of Heuristic Method, Genetic Algorithm and Artificial Neural Network is recorded varying other parameters. Throughput in the figures is the percentage of best theoretical case to the throughput achieved by Genetic Algorithm. The graphs in Figure 3, Figure 4, Figure 5, Figure 6 and Figure 7 compare

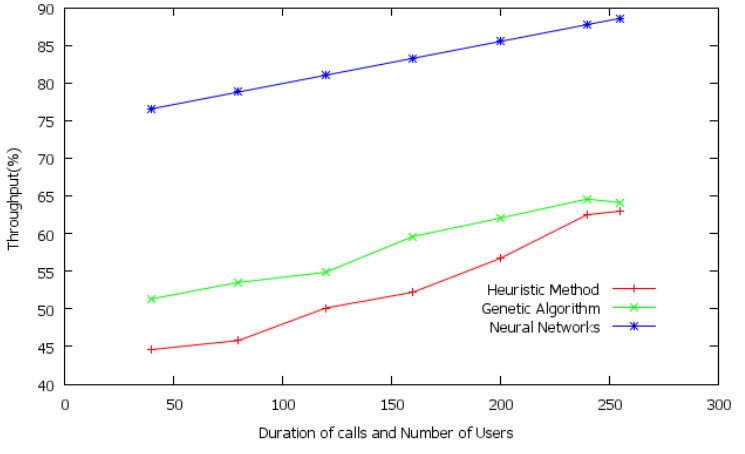

Fig. 3. Performance of Heuristic Method, Genetic Algorithm and Neural Networks with Parameters Duration of calls and Number of Users fixed at different Intervals

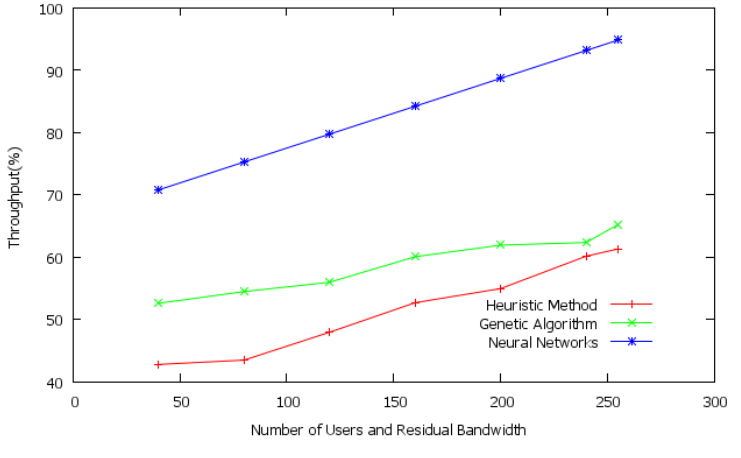

Fig. 4. Performance of Heuristic Method, Genetic Algorithm and Neural Networks with Parameters Number of Users and Residual Bandwidth fixed at different Intervals

the throughput performance of Heuristic method, Genetic Algorithm and Artificial Neural Network for different parameters. From the graphs, it is clear that Neural Networks outperform other methods.

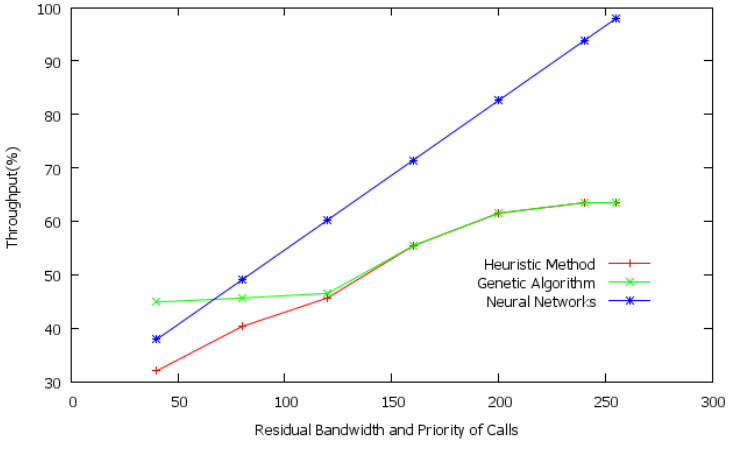

Fig. 5. Performance of Heuristic Method, Genetic Algorithm and Neural Networks with Parameters Residual Bandwidth and Priority of calls fixed at different Intervals

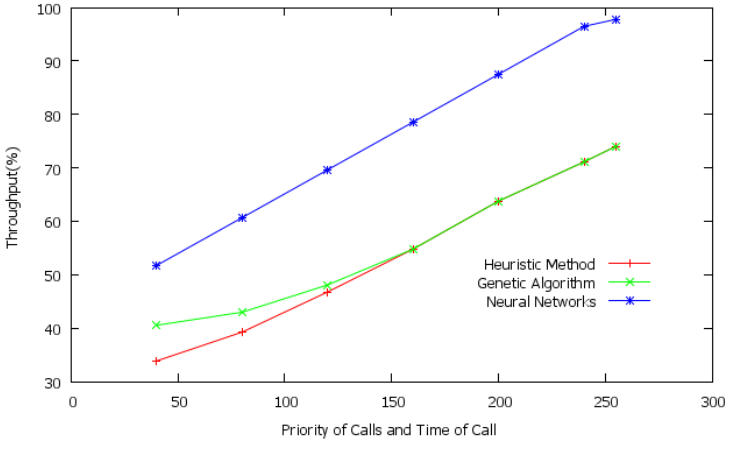

Fig. 6. Performance of Heuristic Method, Genetic Algorithm and Neural Networks with Parameters Priority of calls and Time of Call fixed at different Intervals

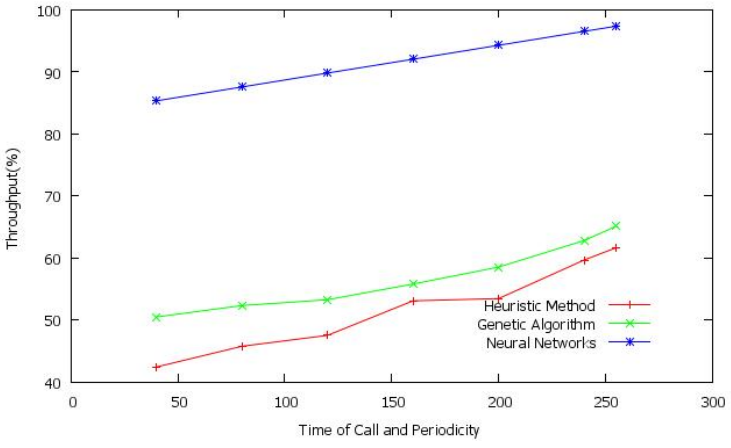

Fig. 7. Performance of Heuristic Method, Genetic Algorithm and Neural Networks with Parameters Time of Call and Frequency of Calls fixed at different Intervals

6 Conclusion

The quality of service parameters such as Duration of Call, Number of Users, Residual Bandwidth, Priority, Time of Call and Frequency of Calls are considered for channel allocation problem. Genetic Algorithm and Artificial Neural Networks are applied on these parameters for optimization of channel allocation. From the results obtained, it can be concluded that application of Genetic Algorithm increases the throughput compared to heuristic method. But application of Artificial Neural Network gives the maximum throughput compared to the other methods.

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