Journal of the Nigerian Association of Mathematical Physics
***Volume35,(May, 2016*), pp 431 – 438**
© J. of NAMP

An Adaptive Channel Allocation Scheme for Handoff Prioritization and Acceptable QoS for New Calls in Mobile Networks

[1]Ojesanmi O.A, [2]Ugege P., and [3]Folorunso O.

Department of Computer Science, Federal University of Agriculture, Abeokuta.

Abstract

Most existing handover management schemes have the common characteristics of reducing the call dropping probability at the expense of increased call blocking probability; this leads to a poor quality of service (QoS) for new calls. Though there is need to give priority to handoff calls as it is more frustrating to have an ongoing call dropped than blocking a new call, there is need to balance this prioritization with the provision of an acceptable (QoS) for the new calls. One thing common to most handover management schemes is the reservation of some set of channels for the exclusive use by handoff calls. And so even when these channels are free, new calls could still be blocked if none of the general channels is available to be allocated to the new call. This has not proved to be an efficient approach to attaining optimality in the utilization of the network limited channels resources. We therefore propose the use of multiple parameters (Call drop probability and traffic intensity) rather than a single parameter to decide when to grant new calls access the reserved channels. We also propose the need to keep the number of channels to reserve fixed rather than calculating the numbers to reserve per time therefore reducing the computational complexity of the scheme.

Keywords: Channels, Handover, Mobile Network, Quality of Service, Traffic Intensity, Call Drop Probability

1.0 Introduction

Handover is the procedure that transfers an ongoing call from one cell to another cell as the user moves through the coverage area of cellular system. As a result of the cellular architecture employed to maximize spectrum utilization in mobile networks, efficient handover mechanism is extremely important. One way to improve the cellular network performance is to use efficient handover prioritization schemes when user is switching between the cells [1,2,3].

Each handover require network resources to route the call to next base station and if handover does not occur at the right time the Quality of Service (QoS) may drop below an adequate level and connection will be dropped. The purpose of the handover procedure is to preserve ongoing calls when the mobile station is moving from one cell to another [4,5]. Having an ongoing call dropped is more frustrating to a customer than blocking a new call. As a result most existing handover schemes often give priority to handoff calls at the expense of poor quality of service for new calls. Channels are kept idle waiting to be used for handoff calls even when new calls are being blocked for none availability of frequency resources to allocate for the use of the new calls. This has brought about the need for more efficient schemes that can adequately provide an acceptable QoS for both handoff calls and new calls in mobile networks. Such schemes will also reduce congestions in mobile networks.

Different ideas and approaches are proposed to reduce the handoff dropping probability. One approach is to reduce the handover failure rate by prioritizing handoff call over new calls [6]. Basic methods in handover prioritization schemes are guard channels (GC), call admission control (CAC) and handover queuing schemes. Sometimes these schemes are combined together to obtain better results.

In Guard Channel scheme the probability of successful handover is improved by simply reserving a number of channels exclusively for handoff calls in each cell. The remaining channels are equally accessed by handover and new calls. In the call admission control scheme, a decision is made whether new call requests are admitted into the network or not. In the CAC the arrival of new call are estimated continuously and if they are higher than the predefined threshold level then some calls are restricted (blocked) irrespective of whether a channel is available or not to decrease the probability of handoff call.

Corresponding author: Ojesanmi O.A, E-mail:ojesanmioa@funaab.edu.ng, Tel.: +2348056052007

In Queuing handoff call prioritization scheme [6], the handoff calls are queued when all the channels are occupied. When a channel is available, it is assigned to one of the handover calls in the queue. One thing that is common to these schemes is the fact that they decrease the call dropping probability at the expense of an increased call blocking probability. This paper proposes an algorithm that will provide an acceptable QoS for new calls while guaranteeing the QoS of handoff calls.

2.0 Literature Review

An adaptive channel assignment scheme that divides the network channels into guard channels and shared channels was proposed by [4]. Markovian model was used to estimate a threshold by based the traffic intensity. Based on the threshold, the cells can be classified into two classes. When the channel occupancy of a cell is less than threshold, this is a cold cell. Otherwise, it is a hot cell. Next, if a cell is in cold state, it can accept both kinds of calls, the new call and the handoff call. If it is in hot state, the handoff calls only. However, calculating the number of channels to reserve for handover calls all the time added to the computational time of this approach. Also they considered only one parameter in deciding how many channels to reserve for the handover calls only.

A new Adaptive channel allocation scheme (ACAS) for cellular networks was presented [5]. The proposed algorithm adjusts the number of guard channels dynamically depending on the dropping rate of handoff calls in a certain period of time. It keeps the handoff call rejection rate below the given threshold and it also reduces the new call rejection rate a bit by decrementing the number of guard channels when it is observed to be more than needed. This work focused on controlling the number of guard channels to be reserved for handover calls depending on the call dropping rate over time. Hence channels are sometimes reserved and left idle because handover calls are fewer than estimated since the traffic intensity was not considered. Meaning channels are reserved for handover calls at the expense of blocking new calls even when such reserve is not necessary because not all necessary parameters were considered.

A reliability based channel allocation model for mobile networks was developed [7]. The model used a GA approach to optimize both objectives such as number of channels and the number of blocked hosts. The proposed model was an effective approach to make the network connections more reliable by the proper management and efficient usage of the channel reuse factor. This greatly increased the number of channels to avoid congestion in the network.

In [3], a two-tier system is proposed with Guard-Channels that are reserved to handle the handoff calls only. The aim of this work is to improve the performance of new calls by using overlapping property of the two-tier system that provides the advantage to share the traffic load with frequency sharing techniques in between micro-macrocell. By using the overlapping property of two-tier system the load of the cell may be transferred from lower tier to upper tier and vice-versa.

A hybrid channel allocation mechanism as a combination of fixed channel allocation and dynamic channel allocation was introduced [8]. The algorithm of the mechanism minimizes the probability of call blocking and call dropping by considering hybrid channel borrowing technique and cell-based channel distribution technique. To reduce the communication overhead due to information gathering about base stations (BSs), they used a coupon based mechanism. They gave more importance to handoff calls. The simulation result shows the reduction in the dropping rate of handoff calls and blocking rate of fresh calls by implementing disaster channel management.

A technique with adjustable guard channels that controls the number of guard channels reserved for handover channel by looking at the traffic intensity was developed [9]. Basing the decision to increase or decrease the guard channels on comparing the number of calls and total open access channels, the issues of channel reuse is totally left out of consideration.

3.0 Methodology

We propose an enhanced handover algorithm that is an improvement on the works in[4,5,7].Our improvements on existing works are centered on the following:

(i) The new algorithm intends to use multiple parameters (call drop probability and traffic intensity) to decide the accessibility to the fixed nominal channels by new calls.

(ii) Also the proposed algorithm will give special consideration to the handover calls while ensuring as much as possible an acceptable QoS for new calls by not reserving channels for none existing handover calls at the expense of new calls blocking.

(iii) There is also a reduction in the computational time involved in the dynamic adjustment of the number of channels reserved for handover calls by keeping the number of nominal fixed channels constant and rather dynamically control the access to the channels by new calls.

(iv) The proposed algorithm (Figure 1) takes into account the traffic intensity and blocking probability in a cell. Both parameters are used to determine if access to the nominal channels should be exclusively for handover calls or all calls. The algorithm therefore ensures that nominal channels are not kept for handover calls when it is not necessary to do so. This is intended to achieve an optimal utilization of the channel resources while maintaining an acceptable QoS for both handover and new calls.

(a) Parameters for the algorithm:

— TI = traffic intensity = (Avail_nom_cha/Tot_nom_cha)

- CBP = call blocking probability = NC_rej/ Tot_N_calls
- CDP = call dropping probability = HC_rej/ Tot_H_calls
- H_calls = handover/handoff calls
- N_calls = New calls
- TI_threshold = Traffic intensity threshold
- CDP_threshold = Call drop probability threshold
- HC_rej = Handover calls rejected
- NC_rej = New calls rejected
- Tot_H_calls = Total Handover calls = H_calls + HC_rej
- Tot_N_calls = Total New calls = N_calls + NC_rej
- Avail_nom_cha =available nominal channel (Tot_nom_cha – Nom_cha_used)
- Tot_nom_cha = Total nominal channels
- Nom_cha_used = Nominal channels in use

```
BEGIN
For every call that arrives in cell K
IF call is handoff call
    IF fixed channel is available
        Assign fixed channel
        H_calls = H_calls +1
        Nom_cha_used = Nom_cha_used +1
    ELSE
        Search for dynamic channel
        IF channel is available
            Assign dynamic channel
            H_calls = H_calls +1
        ELSE
            Block call
            HC_rej = HC_rej + 1
IF call is new call
Find TI
Find CDP
IF TI and/or CDP > threshold value (TI_threshold/CDP_threshold)
    Search for dynamic channel
        IF channel is available
            Assign dynamic channel
            N_calls = N_calls +1
        ELSE
            Block call
            NC_rej = NC_rej +1
ELSE
    IF fixed channel is available
        Assign fixed channel
        N_calls = N_calls +1
        Nom_cha_used = Nom_cha_used +1
    ELSE
        Block call
        NC_rej = NC_rej + 1
IF a call is completed
IF channel used for completed call is a nominal channel
Nom_cha_used = Nom_cha_used -1
END
```

Figure 1: Proposed Algorithm

(b) Dynamic Channel Allocation

A neuro-genetic dynamic channel allocation approach is also proposed in this work. The approach combines Neural network and Genetic algorithm to decide the best channel (optimally selected channel) to allocate to a call from the central pool. The approach considers both the electromagnetic hard constraints (Co-channel constraint (CCC), adjacent channel constraint (ACC) and Co-site constraint (CSC)) and the soft conditions (Parking condition (PC), Limiting Rearrangement

(LR) and Resonance condition (RC).

All three hard constraints is represented with a compatibility matrix C which is an N x N symmetric matrix as shown in equation (1), where N is the number of cells in the network.

$$C = \begin{pmatrix} C_{11} & C_{12} & . & . & . & C_{1N} \\ C_{12} & C_{22} & . & . & . & C_{2N} \\ . & . & . & & & . \\ . & . & & . & & . \\ . & . & & & . & . \\ C_{N1} & C_{N2} & . & . & . & C_{NN} \end{pmatrix} \quad (1)$$

The :

(i) Each diagonal element C_{ii} shows the CSC, which is the minimum separation in frequency between any two channels at cell i.

(ii) If $C_{ij} = 0$; there is no constraint in channel reuse in between cell i and j.

(iii) If $C_{ij} = 1$; there is a CCC, If $C_{ij} = 2$; there is a ACC and If $C_{ii} >= 1$; there is a CSC.

An allocation channel by cell matrix A, in equation (2), reflects which channel has been allocated to which cell. $A_{i,j}$ is 1 if channel j is assigned to cell i and 0 otherwise .

$$A = \begin{pmatrix} A_{1,1} & A_{1,2} & . & . & . & A_{1,cel} \\ . & & & & & , \\ . & & & & & . \\ . & & & & & . \\ . & & & & & . \\ A_{cha,1} & A_{cha.2} & . & . & . & A_{cha,cel} \end{pmatrix} \quad (2)$$

Also, a demand vector, D, of dimension $\{d_1 \ldots d_N\}$, in equation (3), where d_i is the number of channels required in cell i in order to satisfy channel demand.

$$D = \left(d_1, d_2, \ldots, d_N \right) \quad (3)$$

In addition to the hard constraints the approach also considers the soft constraints to address the need to optimize channel reuse across the network. The set of equations (4) to (9) defines the proposed approach to the formulation and representation of the Channel allocation Problem (CAP) as an optimization problem incorporating all three hard constraints (CCC, CSC and ACC) and soft conditions (PC, RC and LR). Equations (4) and (5) are similar to the functions used in[10] to represent the CCC, ACC and CSC hard constraints. Equations (6), (7) and (8) are similar to functions used in[11] to represent the soft conditions. We have introduced equation (9) to the combined functions used separately in[10] and [11] to arrive at equation (10) which is now our new optimization function for the CAP problem in this work. We have also dropped the weights introduced in[11] to determine the importance of the various terms in the formulation because they don’t seem to really have a clear role in determining the optimality of the function.

(c) Parameters used in the equations:

— cel = Number of cells in the network

— cha = Number of dynamic channels in the central pool

— k = cell in which a call arrived ($1 \le k \le cel$)

— $E_{ACC,CCC}$ = Energy function for adjacent channel and co-channel constraints

- $ACCC_{kjip}$ =Adjacent channel and co-channel constraint between channel j selected by cell k and channel p used by cell i
- CSC_{jp} = Co-site constraint between channel j and channel p selected for use in the same cell
- E_{PC} = Energy function for packing condition
- E_{RC} = Energy function for resonance condition
- RC_{ik} = function determining whether cell I and k belong to same reuse scheme
- E_{LR} = Energy function for limiting resonance
- Mcha = Maximum number of dynamic channels allowed for use in a cell
- E_{Mcha} = Energy function for Mcha
- CCC_{ik} = co- channel constraint between cell i and k for using same channel
- $dist_{ik}$ = distance between cell i and k in the network

$$E_{ACC,CCC} = \sum_{j=1}^{cha}\sum_{i=1}^{cel}\sum_{p=1}^{cha} V_{k,j} * A_{i,j} * ACCC_{kjip} \tag{4}$$

v

$$ACCC_{kjip} = \begin{cases} 1\ if i \neq k and C_{ki} > 0\ and j - (C_{ki} - 1) \leq p \leq j + (C_{ki} - 1) \\ 0 \quad otherwise \end{cases}$$

Equation (4) states the adjacent channel constraint and co-channel constraint. Both constraints are considered together because they can be represented by the value of $C_{i,j}$ when $i \neq j$. Here $V_{k,j}$=1 if channel j is assigned to cell k, otherwise $V_{k,j}$=0. While k signifies the cell in which call arrives. The energy function $E_{ACC,CCC}$ increases if a channel j which is assigned in cell i is selected for cell k and interference would occur as a result of that selection. It thus ensures that solutions with no interference give better fitness values. $A_{i,j}$ is the ijth element of the assignment table A, which is 1 if channel j is assigned to cell i, and 0 otherwise.

$$E_{CSC} = \sum_{j=1}^{cha}\sum_{p=1}^{cha} V_{k,j} * A_{k,p} * CSC_{jp} \tag{5}$$

where

$$CSC_{jp} = \begin{cases} 1 \quad if j \neq p and p - (C_{kk} - 1) \leq j \leq p + (C_{kk} - 1) \\ 0 \quad otherwise \end{cases}$$

$$E_{PC} = \sum_{j=1}^{cha}\sum_{i=1}^{cel} V_{k,j} * A_{i,j} * \frac{(1 - CCC_{ik})}{dist_{ik}} \tag{6}$$

$i \neq k$

Equation (5) states the *Co-site* constraints this is considered based on the value of C_{jp} in the compatibility matrix C.
Equation (6) states the *packing condition*. The energy decreases if channel j assigned to cell k is also selected by cell i and CCC_{ik} = 0. Energy reduction depends on the distance between i and k. The packing condition requires that a channel, in use in one cell, should be reused in another cell as close as possible without the channels interfering with each other so that the number of channels used by the network is minimal, thereby lowering the probability of future call blocking in other cells. If this condition is satisfied, it further reduces the energy function

$$E_{RC} = \sum_{j=1}^{cha}\sum_{i=1}^{cel} V_{k,j} * A_{i,j} * (1 - RC_{ik}) \tag{7}$$

$i \neq k$

Equation (7) symbolizes the *resonance condition*. Where RC_{ik} is a function whose value is 1 if cells i and k belongs to the same reuse scheme, otherwise 0. The resonance condition tries to ensure that same channels are assigned to cells that belong to the same reuse scheme, as far as possible.

$$E_{LR} = \sum_{j=1}^{cha} V_{k,j} * A_{k,j} \qquad (8)$$

Equation (8) subtracts 1 from the energy function when a channel j assigned in cell k for an existing call before the arrival of a new call, remain the channel assigned to the call in the new configuration as a result of the new call. Limiting rearrangement try to assign, whenever possible, the same channels assigned before to the existing calls, thus limiting the reassignment of channels. Channel reassignment is the process of transferring an ongoing call to a new channel without call interruption. Such reassignment in the entire cellular network upon the arrival of a new call will obviously result in lower call blocking probability, but it is complex, both in terms of time and computation. Therefore, the reassignment processes should be limited to a low level. On this account, limiting rearrangement condition is used to prevent excessive reassignment in a cell [12].

Equation (9) is introduced to discourage channels being allocated to cells that have reached the maximum number of channels (Mcha) specified for each cell in the network. If the number of channels already assigned to a cell requesting for channel has reached Mcha, it will maximize the function value and makes it a lesser choice for selection. That is it will reduce the chances of a channel being selected for allocation to the cell.

$$E_{Mcha} = Mcha - \sum_{j=1}^{cha} V_{k,j} \qquad (9)$$

From equations (4) to (9), the energy function E for cell k becomes

$$\sum_{j=1}^{cha}\sum_{i=1}^{cel}\sum_{p=1}^{cha} V_{k,j} * A_{i,j} * ACCC_{kjip} + \sum_{j=1}^{cha}\sum_{p=1}^{cha} V_{k,j} * A_{k,p} * CSC_{jp} - \sum_{j=1}^{cha}\sum_{i=1}^{cel} V_{k,j} * A_{i,j} * \frac{(1 - CCC_{ik})}{dist_{ik}} +$$

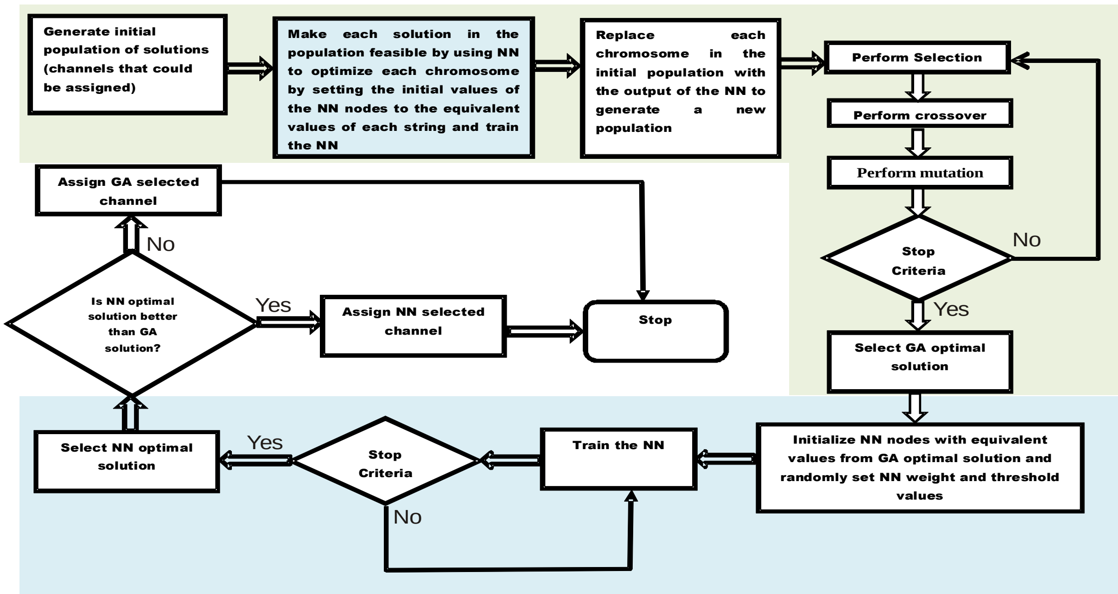
$$\sum_{j=1}^{cha}\sum_{i=1}^{cel} V_{k,j} * A_{i,j} * (1 - RC_{ik}) - \sum_{j=1}^{cha} V_{k,j} * A_{k,j} - \left(Mcha - \sum_{j=1}^{cha} V_{k,j} \right)$$

$$E = E_{ACC,CCC} + E_{CSC} - E_{PC} + E_{RC} - E_{LR} - E_{Mcha} \qquad (10)$$

Our task becomes to optimize the energy function represented in equation (10). This can be minimized using Hopfield neural network with the appropriate interconnection weights and external inputs. However the drawback with the use of neural networks in solving optimization problems is that they can easily get trapped in local optimal and getting an acceptable optimal solution depends on the initial values of the neurons and weights [13]. We therefore propose an approach that combines Genetic algorithm and Neural Network to solve the CAP. Our proposed approach is explained with the flow diagram in Figure 5. The output from this dynamic channel allocation will serve as the optimal channel selected to be assigned to a call from the central pool.

From the proposed architecture (Figure 2), if the incoming call is a handoff call and a channel is available in the reserved fixed nominal channels, the channel is assigned to the call. If a channel is not available an appropriate channel is dynamically searched for in the central pool and allocated to the handoff call. The handoff call only gets dropped if no channel could be assigned through the DCA part of the proposed scheme. However if the incoming call is a new call, the traffic intensity and call drop probability of the network is calculated and depending on the values as compared with sets threshold value the new call could be allocated a channel from the fixed nominal channel or otherwise. If access could not be granted to the new call to use the reserved channel, a channel is searched for from the central pool and assigned. The new call gets blocked if a channel could not be assigned from the central pool.

From the flow diagram in Figure 3, an initial population of solutions (chromosomes) is generated. Each chromosome in the randomly selected initial population of the GA is then used to initialize the values of the NN and trained to produce a feasible solution; the optimal solution.



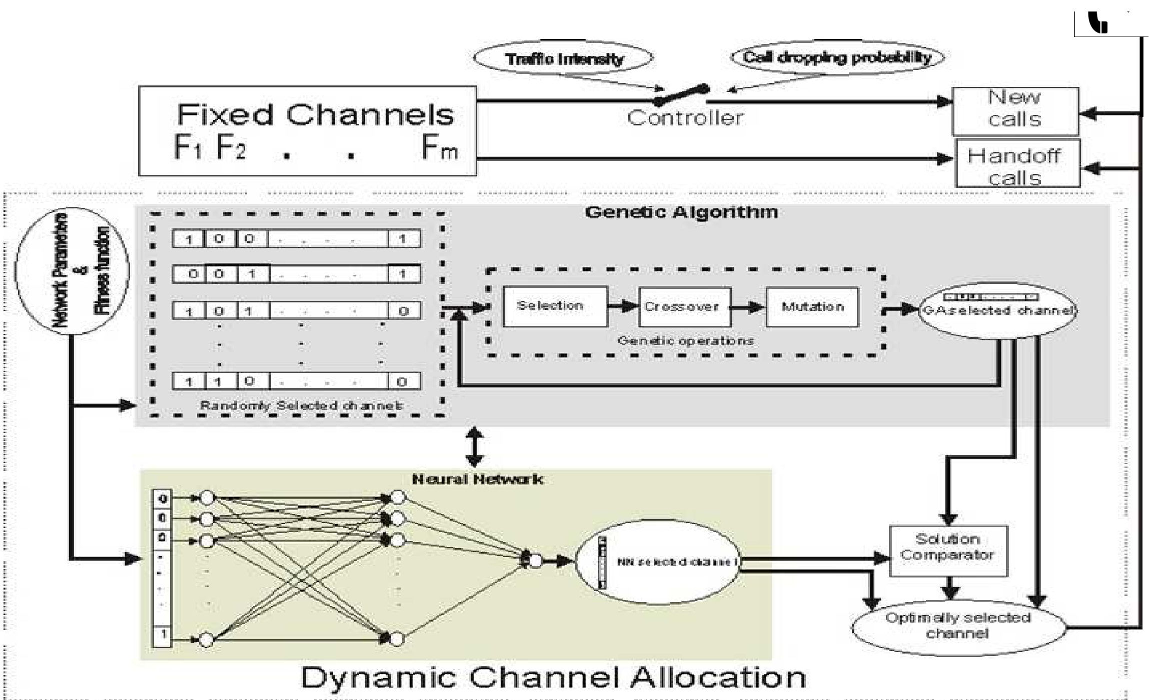


Figure 6: Proposed Architecture

Selection, crossover and mutation to produce an optimal solution. This optimal solution which is expected to be an acceptable near optimal solution is now used to initialize the neural network and trained again to get a possible better optimal solution. This solution now serves as the channel allocation arrangement for the network at the time of channel demand.

4.0 Conclusion

This work proposes a new handoff algorithm that is an improvement on existing works by using multiple parameters (call drop probability and traffic intensity) to decide the accessibility to the fixed nominal channels by new calls. It also attempts to balance the need to give special consideration to handoff calls and providing an acceptable QoS for the new calls. The work equally propose a new neuro-genetic approach to solving the CAP.

5.0 References

[1] Kaur H. and Kaur A. 2014. Various Handover Management Techniques in GSM Cellular System.*International Journal for Technological Research in Engineering*. Volume 1 Issue 11, 1335 – 1338.

[2] Goswani A. M. and Patel S. 2014. Ensuring better QoS through Call Admision Control in Wireless Network. *International Journal of Computer Science and Information Technologies,*Vol. 5(2), 1086 – 1089

[3] Solanki V. and Rafiq M. Q. 2014. Improving the Efficiency of Call Admission Control in Wireless Cellular Communication Network by Frequency Sharing Technology. *International Journal of Computer Trends and Technology,* Volume 9, Number 3, 133 - 146

[4] Nayak S. S., Kar R. R. and Garanayak M. 2015. Adaptive Shared Channel Assignment Scheme for Cellular Network to Improve the Quality of the Handoff Calls. IOSR *Journal of Computer Engineering (IOSR-JCE)* Volume 17 Issue 1, Ver. V. 61 – 67

[5] Kar R. R. and Nayak S. S. 2014. An Efficient Adaptive Channel Allocation Scheme for Cellular Network. *IOSR Journal of Computer Engineering (IOSR-JCE),* Volume 16, Issue 2, 75-79.

[6] Khan J. 2010, Handover Management in GSM Cellular System *International Journal of ComputerApplication*. Volume 8– No.12, 37 - 42

[7] Anujendra A. and Thakurta P. K. G 2014. A New Reliability Based Channel Allocation Model in Mobile Networks. *International Journal of Computer, Information Science and Engineering* Vol. 8, No. 2, 265 – 269

[8] Susil K. S. and Prafulla K. B. 2013 "An Efficient Hybrid Channel Allocation Mechanism in Mobile Network" *International Journal of Research in Engineering & Applied Sciences* Volume 3, Issue 2, pp. 11-30.

[9] Alagu S. and Meyyappau T. 2012. Dynamic Channel Allocation Scheme to Handle Handoff in Wireless Mobile Network. *Computer Sciene and Information Technology (CS & IT)*, 171 – 184.

[10] Moradi O. 2011 A Hopfield Neural Network for Channel Assignment Problem in Cellular Radio Networks. *Computer and information Science,* Vol 4, No 1, pp. 116-129.

[11] Deepak K. S, Srinivas K. and Bhagwan D. 2012. A Dynamic Channel Assignment in GSM Telecommunication Network Using Modified Genetic Algorithm. *Proceedings of the 6th Euro American Conference on Telematic and Information Systems (EATIS' 12), 2012, pp 425 - 42.*

[14] Jamal E. and Zouchair G. 2011 Evolutionary Neural Networks Algorithm for the Dynamic Frequency Assignment Problem. International Journal of Computer Science &Information Technology (IJCSIT), Vol 3, No 3, pp. 49-61.