ALLOCATION SCHEME FOR MULTI-LAYER CELLULAR NETWORK WITH INTEGRATED TRAFFIC

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ABSTRACT

Next generation wireless technology will support mobility for multimedia applications. In this investigation, we develop analytical models for predicting the blocking probabilities in multi layer cellular network providing integrated services to a population of mobile users. The analytical models are based on continuous time multi-dimensional birth-death approach having double layer cellular architecture. There is a provision of reserved channels to give the priority to handoff calls. By using releasing function (RF), the reserved channels may also be allocated to new calls in case when reserved channels are free. The channel assignment technique optimizes the quality of service (QoS) of low speed moving terminals (LSMT) and high speed moving terminals (HSMT). The lower layer of the proposed architecture is based on microcellular architecture, for absorbing the traffic loads of low speed moving terminals (LSMT). The higher layer is based on a macro-cell umbrella solution, for absorbing the traffic load of HSMT in a congested urban area. The provision of subrating of the guard channels (GC) for handoff calls of LSMT in each microcell has been made.

We analyze the performance of channel assignment scheme based on new call bounding, cutoff priority and subrating. To validate the scheme suggested, we provide numerical results. The sensitivity analysis has been carried out to examine the effect of system descriptors on various measures of performance, namely blocking probabilities, carried load, etc.

Keywords : *Cellular network, Multi-layer architecture, Channel allocation, Releasing function, Cutoff priority, Blocking probability.*

1. INTRODUCTION

The telecommunication deregulation has restructured the communication industry all over the world, which has led to business competition in the wireless services market. Since there are usually multiple wireless providers in every region, users have the freedom to choose the provider for their service. More and more operators are looking for cellular technology to provide service to thousands of new subscribers with high quality telephone service at a reasonable price. To increase capacity, the service area is divided into many numbers of micro cells which are overlaid by macro cells. The macro cell/ micro cell overlay architecture provides a balance between maximizing the number of users per unit area and minimizing the network control load associated with handover.

Macro cells provide wide-area coverage beyond micro cell service areas and ensure better inter-cell handover. Micro cells provide high capacity and cover areas with high traffic density. In less congested areas traffic demand is not very high and macrocells can provide adequate coverage.

Cellular network usually deals with the two types of calls i.e. new calls and handover calls. The handoff calls are one, which are already ongoing call from the present cell but have moved onto a new cell and need to connect to a new base station. The blocking probability of the hand off calls is an important GoS metric of mobility management in cellular systems. In addition to traditional voice services, cellular networks are expected to accommodate more and more novel data services that demand direct, reliable and efficient connections. Posher and Guerin (1985) suggested some traffic policies for cellular radio system that minimize blocking of handoff calls. Oh and Taha (1992), Acampora and Naghshineh (1994) presented architecture and methodology for mobile communications that executed handoff calls in cellular networks. Jabbari and Fuhrmann (1997) studied teletraffic modeling and analysis of flexible hierarchical cellular networks with speed-sensitive handoff strategy. Jain (2000) presented prioritized channel assignment in mixed media cellular radio system. Boucherie and Wal (2003) considered transient handover blocking probabilities in road covering cellular mobile networks. The synchronization and handoff call management schemes allow mobile hosts to receive time dependent multimedia streams without delivery interruption while moving from one cell to another cell. Rouskas et al. (2008) studied a game theoretical formulation of integrated admission control and pricing in wireless networks. Touhami et al. (2009) analyzed partial integration of frequency allocation within antenna positioning in GSM mobile networks.

With the fast growing application of multimedia, it has become desirable for wireless cellular networks to deliver broad-band services for integrated traffic which includes voice calls, data calls, and images as well. To support these traffic conditions, cell sizes are decreased which results in an increase in the number of handoffs and the forced termination probabilities. Recently, a new scheme has been reported in the literature, in which a new channel is created for a handoff attempt by subrating an existing cell. Lin et al. (1996) proposed a subrating channel assignment strategy where an occupied full rate channel is divided into two half-rate channels, one to serve the existing call and the other one to serve the hand-off request. Li and Alfa (1999) proposed that only the reserved channels could be splitted into two different rate channels. Jain and Rakhee (2001) suggested subrated channel assignment schemes for integrated traffic. Sheu and Wu (2006) gave a preemptive channel allocation scheme for multimedia traffic. Carvalho et al. (2007) studied performance analysis of multi service wireless network. Iniewski (2008) gave the overview of wireless technology. Flammini and Navarra (2009) studied layouts for mobility management in wireless ATM networks.

A cellular radio system with the provision of finite buffer is more realistic instead of infinite buffer. Chang et al. (1994) studied analysis of a cutoff priority cellular radio system where finite queueing and reneging/ dropping is allowed for queued new calls, but queued handoff attempts are dropped, when they move out of handoff area. By reserving some channels exclusively to serve handoff attempts, there is low utilization of these reserved channels in case of low handoff rate regions. Fancy and Zhang (2002) presented call admission control schemes and performance analysis in wireless mobile networks. Jain and Rakhee (2003) proposed a comparative study of three priority schemes in order to reduce the chance of handoff failure. Beigy and Meybodi (2005) studied an adaptive call admission algorithm for cellular network. Ksentini et al. (2007) analyzed a resource allocation protocol for QoS sensitive services provisioning in the communication networks.

Furukawa and Akaiwa (1994) described a microcell overlaid with umbrella cell system. Yeung and Nanda (1996) suggested channel management in microcell or macrocell cellular radio systems. Davoli and Maryni (2000) suggested a two level approximation for admission control and bandwidth allocation. The network consists of number of layers connected by trunk group. There are two types of layers, (i) macro layer that is the outer and (ii) the micro layer that is the inner layer. The outer layer has connection to subscribers and receives fresh traffic destinated for the network, whereas, the inner layer only deals with traffic inside the network structure.

We consider a communication network consisting of traffic having both new calls and handoff data/voice calls. Our aim in this investigation is to decide the number of channels to be allocated in each call of a cellular system with integrated traffic, so that the blocking probabilities of the new and handoff calls could be reduced. A two layer cellular architecture model is studied in which new calls of both LSMT and HSMT and handoff calls of LSMT are to be admitted to micro calls. There is a provision of reserved channels for handoff calls of LSMT whereas handoff calls of HSMT are to be admitted in umbrella macro call. Two-layer cellular architecture model with buffer and subrating is proposed in first model, whereas in second model two layer cellular architecture with function and subrating is considered. In subrating scheme, the reserved channels of micro cellular calls may be splitted into two half rate channels. A queue for waiting handoff calls of HSMT in umbrella macro call is formed. The channel holding times for new calls and handoff calls are assumed to be different in all the models.

The rest of the paper is structured as follows. In section 2, the Markovian model is described by stating the requisite assumptions and notations being used in the formulation of the mathematical model. There is provision of a finite buffer for hand-off voice attempts to decrease the blocking probability of handoff-voice calls. The subrating of the reserved channels is allowed in order to deal with heavy traffic in section 3. Various performance measures are established in scheme 4. In section 5, the sensitivity analysis has been performed to examine the effect of various parameters on system performance. Finally, conclusions are drawn in section 6.

2. TRAFFIC MODEL

In a cellular network, it is assumed that there are c number of channels among with r number of channels are reserved exclusively for handoff calls. When one or more non-reserved channels are free, the new call is served immediately otherwise it is blocked. Both types of traffic uses the remaining s=(c-r) channels. The provision of splitting of r channels are made so that more handoff calls can be attempted. The following assumptions for modeling purpose are made:

- Cellular system consists of C macrolayers each having M microlayers. The macrolayer has connection to subscribers and receive fresh traffic for the network where as the microlayer only deals with the traffic inside the network structure.
- Both voice and data calls originate in the layers according to Poisson process in cellular network with mean rate $\square_{1N}$ and $\square_{2N}$ respectively. The handoff voice (data) calls are also assumed to arrive in Poisson fashion with mean arrival rates $\square_{1H}$, $\square_{2H}$, $\square_{1HV}$,$\square_{2HV}$.
- The call holding times are exponentially distributed with mean rate □.
- The cell residence times of each portable are also exponentially distributed with mean rate $\tilde{\square}$

Following are the notations used for modeling the system:

M	Number of micro cells in the macro cellular layer.
C	Number of channels in the macro cellular layer.
c	Total number of channels.
r	Number of dedicated channels reserved for handoff calls.
s=(c-r)	Number of channels serving both types of calls.
$\square_{1N}$ ($\square_{2N}$)	Arrival rates of new calls of LSMT (HSMT)
$\square_{1H}$($\square_{\square H}$)	Arrival rates of handoff calls of LSMT (HSMT)
$\square_{1HV}$($\square_{2HV}$)	Arrival rates of handoff calls of LSMT (HSMT)
1/□	Mean channel holding time for new calls
1/$\square_H$	Mean channel holding time for handoff calls
N	Size of buffer in which handoff calls can wait
$\square_{n1}$ ($\square_{n\square}$)	Balking probability of handoff voice calls at LSMT (HSMT)
$P_{n1,\, n2}$	The steady state probabilities that n1 and n_2 channels are occupied by new calls and handoff calls in a micro cell
B_{n1} (B_{n2})	Blocking probability of new calls at LSMT (HSMT)
B_{1H} (B_{2H})	Blocking probability of handoff calls at LSMT (HSMT)
B_{1HV} (B_{2HV})	Blocking probability of handoff voice calls at LSMT (HSMT)
B	Overall blocking probability of the calls
C_L	Carried load

We denote

$\lambda_n = \lambda_{n1} + \lambda_{n2}$, $\lambda_H = \lambda_{1H} + \lambda_{2H}$ & $\lambda_{HV} = \lambda_{1HV} + \lambda_{2HV}$

3. DOUBLE LAYER ARCHITECTURE

We consider a two layer cellular architecture, which is dedicated to different types of subscribers according to their speed and the type of calls (new or handoff) in some geographical area. The two layer cellular architecture has two layers: the lower layer is the micro cellular layer, which has M microcells and other are higher layer i.e. a macro cell layer. r channels out of c channels are exclusively reserved to serve voice/data handoff calls. When a new call is originated in a cell where less than c-r (=s) channels are busy, it is connected with a channel, whereas in case of more than s busy channels, it is blocked immediately. However handoff attempts get connected to a channel in that cell. Whenever a call finds all the c channels busy then only handoff voice calls are allowed to wait in the buffer and the data handoff calls are blocked. Handoff voice calls are also blocked due to buffer overflow.

In this section, we develop two traffic models for double layer structure in which we have proposed schemes (i) Subrating with Buffer (SB) (ii) Subrating with Buffer and Releasing Function (SBF), respectively.

3.1. Subrating with Buffer (SB)

The subrating scheme is suggested to enhance the capacity to serve more handoff attempts. When all the c channels are busy and a new voice or handoff voice call originated, a new channel is created by subrating of a reserved channel to serve that call on the blocked port. The handoff voice calls wait in the buffer till the channel gets free. The data calls are not allowed to wait in the buffer. Using the appropriate birth death rates as depicted in Fig.1, we obtain the steady state probabilities with the help of product type solution (c.f. Kleinrock, 1985) as.

$$P_{n_1,n_2} = \begin{cases} \dfrac{\lambda_1^{n1}\lambda_2^{n2}}{n_1!n_2!(\mu_1+\eta_1)^{n_1}(\mu_2+\eta_2)^{n_2}}, & 0<n_1+n_2\le c-r \\ \dfrac{\lambda_1^{c-r}\lambda_2^{c-r}\lambda_{1H}^{n_1-c+r}\lambda_{2H}^{n_2-c+r}}{n_1!n_2!(\mu_1+\eta_1)^{n_1}(\mu_2+\eta_2)^{n_2}}, & c-r<n_1+n_2\le c \\ \dfrac{\lambda_1^{c-r}\lambda_2^{c-r}\lambda_{1H}^{r}\lambda_{2H}^{r}\lambda_{1HV}^{n_1-c}\lambda_{2HV}^{n_2-c}}{n_1!n_2!(\mu_1+\eta_1)^{n_1}(\mu_2+\eta_2)^{n_2}}, & c<n_1+n_2\le c+r \\ \dfrac{\lambda_1^{c-r}\lambda_2^{c-r}\lambda_{1H}^{r}\lambda_{2H}^{r}\lambda_{1HV}^{n_1-c}\lambda_{2HV}^{n_2-c}\beta_1^{n_1-c-r}\beta_2^{n_2-c-r}}{n_1!n_2!(\mu_1+\eta_1)^{n_1}(\mu_2+\eta_2)^{n_2}}, & c+r<n_1+n_2\le c+r+N \end{cases} \quad \ldots(1)$$

From the normalization equation, we get,

$$P^{-1}_{0,0} = \left[\sum_{n_1+n_2=0}^{c-r} \frac{\lambda_1^{n_1}\lambda_2^{n_2}}{n_1!n_2!(\mu_1+\eta_1)^{n_1}(\mu_2+\eta_2)^{n_2}} + \sum_{n_1+n_2=c-r+1}^{c} \frac{\lambda_1^{n_1}\lambda_2^{n_2}\lambda_{1H}^{n_1-c+r}\lambda_{2H}^{n_2-c+r}}{n_1!n_2!(\mu_1+\eta_1)^{n_1}(\mu_2+\eta_2)^{n_2}} + \sum_{n_1+n_2=c+1}^{c+r} \frac{\lambda_1^{c-r}\lambda_2^{c-r}\lambda_{1H}^{r}\lambda_{2H}^{r}\lambda_{1HV}^{n_1-c}\lambda_{2HV}^{n_2-c}}{n_1!n_2!(\mu_1+\eta_1)^{n_1}(\mu_2+\eta_2)^{n_2}} + \sum_{n_1+n_2=c+r+1}^{c+r+N} \frac{\lambda_1^{c-r}\lambda_2^{c-r}\lambda_{1H}^{r}\lambda_{2H}^{r}\lambda_{1HV}^{n-c}\lambda_{2HV}^{n_2-c}\beta_1^{n_1-c-r}\beta_2^{n_2-c-r}}{n_1!n_2!(\mu_1+\eta_1)^{n_1}(\mu_2+\eta_2)^{n_2}} \right] \ldots(2)$$

PERFORMANCE INDICES

Various performance indices are established using steady state probabilities as follows.

- Blocking probability of new calls is given by

$$B_n = \sum_{n_1+n_2=c-r}^{c+r+N} P_{n_1,n_2}$$

…(3)

- Blocking probability of handoff data is given by

$$B_h = \sum_{n_1+n_2=c}^{c+r+N} P_{n_1,n_2}$$

…(4)

- The blocking probability of handoff voice call is given by

$$\mathrm{B_{hv}} = \sum_{\mathrm{n_1+n_2=c+r}}^{\mathrm{c+r+N}} \mathrm{P_{n_1,n_2}}$$

…(5)

- The overall blocking probability is calculated as

$$B = \frac{\lambda_n B_n + \lambda_h B_h + \lambda_{hv} B_{hv} (1-\beta_2)}{\lambda}$$

…(6)

- We obtain carried load using

$$CL = \frac{\lambda_n (1-B_n) + \lambda_h (1-B_h) + \lambda_{hv} (1-B_{hv})(1-\beta_2)}{\lambda}$$

…(7)

3.2. Subrating with Buffer and Releasing Function (SBF)

In this scheme, we assume that reserved channels may also be occupied by new attempts with a certain non-zero probability factor strictly less than unity. The reserve channel releasing function f(i) is chosen as a decreasing function of the chance of occupying reserved channels by new traffic load. For this purpose, we suggest $f(i) = \frac{1}{2\sqrt{i}}$ where i=1,2,….r. The steady state probabilities are obtained as

$$P_{n_1,n_2} = \begin{cases} \dfrac{\lambda_1^{n_1} \lambda_2^{n_2}}{n_1! n_2! (\mu_1+\eta_1)^{n_1} (\mu_2+\eta_2)^{n_2}} & 0 < n_1+n_2 \le c-r \\[2ex] \dfrac{\lambda_1^{c-r} \lambda_2^{c-r} \prod_{i=c-r+1}^{n_1} \{\lambda_{1H} + f(i-s)\lambda_1\}}{n_1! n_2! (\mu_1+\eta_1)^{n_1}} \times \dfrac{\prod_{i=c-r+1}^{n_2} \{\lambda_{2H} + f(i-s)\lambda_2\}}{(\mu_2+\eta_2)^{n_2}} & c-r < n_1+n_2 \le c \\[2ex] \dfrac{\lambda_1^{c-r} \cdot \lambda_2^{c-r} \prod_{i=c-r+1}^{n_1} \{\lambda_{1H} + f(i-s)\lambda_1\} \cdot \lambda_{1HV}^{n_1-c}}{n_1! n_2! (\mu_1+\eta_1)^{c-r+n_1}} \times \dfrac{\prod_{i=c-r+1}^{n_2} \{\lambda_{2H} + f(i-s)\lambda_2\} \cdot \lambda_{2HV}^{n_2-c}}{(\mu_2+\eta_2)^{c-r+n_2}} & c < n_1+n_2 \le c+r \\[2ex] \dfrac{\lambda_1^{c-r} \cdot \lambda_2^{c-r} \prod_{i=c-r+1}^{n_1} \{\lambda_{1H} + f(i-s)\lambda_1\} \cdot \lambda_{1HV}^{n_1-c} \cdot \beta_1^{n_1-c+r}}{n_1! n_2! (\mu_1+\eta_1)^{n_1} (\mu_2+\eta_2)^{n_2}} \times \dfrac{\prod_{i=c-r+1}^{n_2} \{\lambda_{2H} + f(i-s)\lambda_2\} \cdot \lambda_{2HV}^{n_2-c} \cdot \beta_2^{n_2-c+r}}{(c+r)^{c-r+n_1+n_2}} & c+r < n_1+n_2 \le c+r+N \end{cases}$$

.

…(8)

From the normalization condition, we get

$$P_{0,0} = \left\{ \begin{array}{l} \displaystyle\sum_{n_1+n_2=0}^{c-r} \frac{\lambda_1^{n_1}\lambda_2^{n_2}}{n_1!n_2!(\mu_1+\eta_1)^{n_1}(\mu_2+\eta_2)^{n_2}} + \sum_{n_1+n_2=c-r+1}^{c} \frac{\lambda_1^{c-r}\lambda_2^{c-r}\prod_{i=c-r+1}^{n_1}\{\lambda_{1H}+f(i-s)\lambda_1\}}{n_1!n_2!(\mu_1+\eta_1)^{n_1}} \\ \times \dfrac{\prod_{i=c-r+1}^{n_2}\{\lambda_{2H}+f(i-s)\lambda_2\}}{(\mu_2+\eta_2)^{n_2}} + \displaystyle\sum_{n_1+n_2=c+1}^{c+r} \frac{\lambda_1^{c-r}\cdot\lambda_2^{c-r}\prod_{i=c-r+1}^{n_1}\{\lambda_{1H}+f(i-s)\lambda_1\}\cdot\lambda_{1HV}^{n_1-c}}{n_1!n_2!(\mu_1+\eta_1)^{c-r+n_1}} \\ \\ \times \dfrac{\prod_{i=c-r+1}^{n_2}\{\lambda_{2H}+f(i-s)\lambda_2\}\cdot\lambda_{2HV}^{n_2-c}}{(\mu_2+\eta_2)^{c-r+n_2}} + \displaystyle\sum_{n_1+n_2=c+r+1}^{c+r+N} \frac{\lambda_1^{c-r}\cdot\lambda_2^{c-r}\prod_{i=c-r+1}^{n_1}\{\lambda_{1H}+f(i-s)\lambda_1\}\cdot\lambda_{1HV}^{n_1-c}\beta_1^{n_1-c+r}}{n_1!n_2!(\mu_1+\eta_1)^{n_1}(\mu_2+\eta_2)^{n_2}} \\ \times \dfrac{\prod_{i=c-r+1}^{n_2}\{\lambda_{2H}+f(i-s)\lambda_2\}\cdot\lambda_{2HV}^{n_2-c}\cdot\beta_2^{n_2-c+r}}{(c+r)^{c-r+n_1+n_2}} \end{array} \right.$$

…(9)

PERFORMANCE INDICES

Blocking probability of new calls is

$$B_n = \sum_{n=c-r}^{c} P_{n_1,n_2}\{1-f(n_1+n_2-(c-r))\} + \sum_{c+1}^{c+r+N} P_{n_1,n_2}$$

…(10)

Other performance measures are obtained by the same formulae as given by equations (3) – (7) for scheme SB.

4. ALLOCATION ALGORITHM

In this section, we develop an algorithm that minimizes the blocking probability of new calls with constraints on the dropping probabilities of handoff calls.

To find out an optimal combination (C, s, c) of the channels in each cell that minimize the overall handoff call blocking probability, the nonlinear integer programming problem (NIPP) can be formulated as follows:

NIPP:

Minimize B_n (C, s, c)

Subject to

$$B_H(\mathrm{C, s, c}) \leq P_{H1}$$
$$B_{H2}(\mathrm{C, s, c}) \leq P_{H2}$$

$$s, c \geq 0$$

Here P_{H1} and P_{H2} ($\leq P_{H1}$) are the minimum level of grade of service (GOS) to be satisfied by handoff calls. To solve NIPP we suggest an algorithm, which is called MinBlock.

MinBlock Algorithm

if B_{H2}(C, C, C) ≤ P_{H2} **then**
  return (C, C)
end if
set c ← C
while (B_{H2} (C, s, c) ≥ P_{H2}) **do**
  set c ← c-1
end while
set s ← c
while (B_H (C, s, c) ≥ P_{H1}) **do**
if (B_{H2} (C, s,c+1) > P_{H2}) **then**
  set c ← c+1
else
  set s ← s-1
end if
end while
return (s, c)
end algorithm

5. NUMERICAL ILLUSTRATION

In the present section, the numerical results are obtained in order to provide the comparison between different indices. We compute the optimal number of shared channels by taking numerical illustrations and using the algorithm developed in the previous section. Furthermore, we compute the various blocking probabilities by taking P_{h1}<1.234 and P_{h2} < 1.456. Table 1 displays the optimal number of s and c using minblock algorithm by varying C. The various performance indices namely blocking probability of new calls, blocking probability of handoff calls and blocking probability of handoff voice calls for all schemes are also tabulated. To examine the effect of arrival rate □$_1$ and □$_2$ on the metrics B_n, B_h, B_{hv}, B, CL are depicted in Table 2 and Table 3. From these tables, it is observed that by increasing the arrival rates of new calls in LSMT, the blocking of handoff (B_h) is increased whereas the overall blocking (B) decreases and carried load is increased for scheme SB.

In table 4 and table 5, we give performance indices for different values of □$_1$ and □$_2$ foe scheme SBF. The effect of parameters on performance measures is similar as in Table 2 and Table 3. It is found that B_n and B decreases whereas Bh increases with increase in□$_{1.}$

Figure 2(a-c) depicts the relationship of the new call blocking probability B_n , handoff blocking probability B_h and handoff voice blocking probability $B_{hv,}$ respectively with the arrival rates of the new calls for different values of the number of total channels for SB(dotted lines) and SBF(dark lines), it can be noticed that all the blocking probabilities show the increasing trends with the arrival rate. Further, it can be seen that all the blocking probabilities increase by increasing the number of channels.

In fig. 3(a), the blocking of new calls slightly decreases by varying arrival rates □$_2$ for SB for the different number of total channels. The blocking of new calls increases with the increases in arrival rate□$_2$ for SBF. In figs. 3(b-c), for c=10-14, the blocking of handoff calls decreases with the increase in arrival rate□$_2$ for different number of channels in case of both schemes.

In figs. 4(a-c), we demonstrate the trends of blocking probabilities B_n, B_h and $B_{hv,}$ respectively by varying □$_{1h.}$ for c=10-14, we noticed that in beginning there is decreasing but as□$_{1h}$ is increases, there is trends of the blocking probability of new calls for scheme SB. For c=10-14, the blocking of new calls increases with the increases in handoff arrival rate for scheme SBF. In fig. 5(a-c), display the blocking probabilities of B_n, B_h and $B_{hv,}$ respectively by varying □$_{2h}$ in both schemes. It can be noticed that the blocking probabilities of all the calls show increasing trends with the arrival rates as we expect.

In fig. 6(a-c) and 7(a-c) shows that scheme SBF is much better than SB. The reason for this is due the fact that the channels are exclusively reserved for handoff voice calls in SB and the function is used to allocate these channels for □$_{2hv}$ in SBF. For c=10-14, if the blocking of new calls decreases with the increases in handoff voice arrival rate □$_{2\ hv}$ for scheme SB. For c=10-14, the blocking of new calls tends to be constant for SBF for c=10-14, if the blocking of new calls decreases with the increases in handoff voice arrival rate □$_{1hv}$ for scheme SB and SBF. In fig. 8(a-b) and 9(a-b), for c=10-14, if the blocking of new calls decreases with the increases in □$_1$ scheme SB and SBF. In fig. 8(c), if the blocking of handoff voice calls decreases with the increases in □$_1$ for SB and for c=10-14, the blocking of handoff voice calls tends to be constant for SBF.

Overall, releasing function used in channel allocation for providing service to handoff voice calls reduces blocking to the new calls also.

6. CONCLUSION

The future success of the next generation communication systems depends on its ability to efficiently accommodate integrated traffic and services to provide a variety of applications having different quality of service requirements. The suggested assignment strategies can be easily implemented for a double layer cellular system. To support integrated traffic, a pre-specified grade of service can be achieved by incorporating the subrating with buffer (SB) and subrating with buffer and releasing function (SBF). The explicit formula derived may be helpful to reduce the overall call blocking probability by providing the adequate number of guard channels and selecting the right releasing function.

All the schemes are validated by taking numerical illustrations which ensure that these can be implemented successfully in real time wireless systems. SB offers a finite buffer to the handoff voice calls to avoid the forced termination of these calls. The numbers of channels for serving these calls are increased by subrating the reserved channels. In SBF, to deal with heavy load of new calls in comparision to handoff calls, the new calls have the facility to occupy the reserved channels also.

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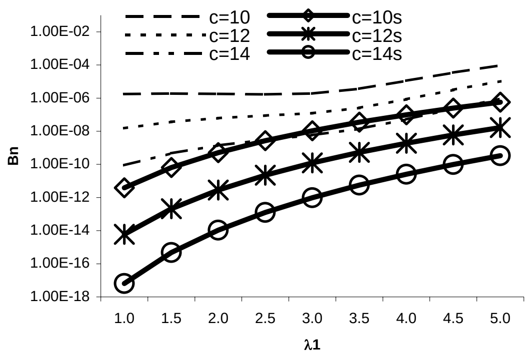

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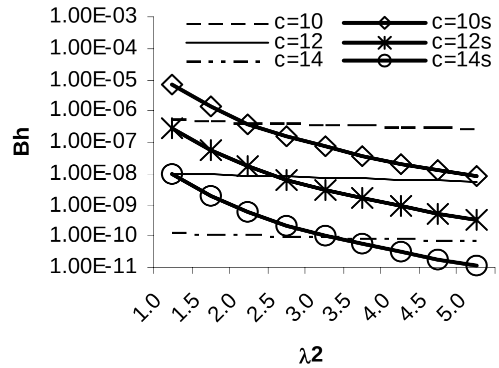

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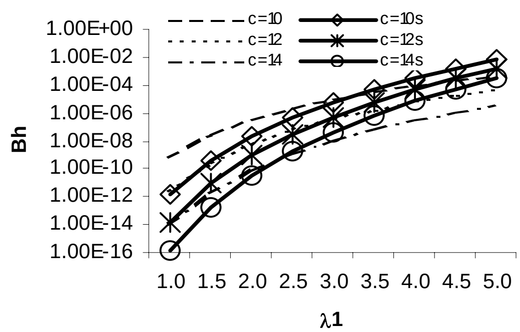

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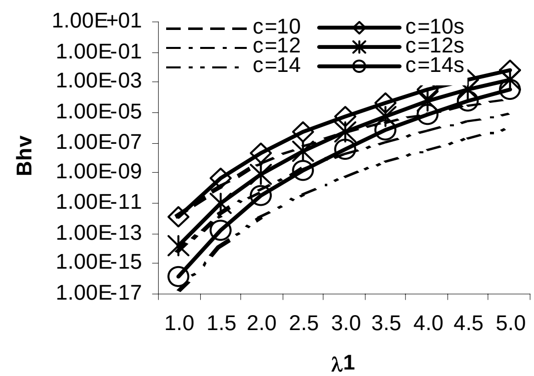

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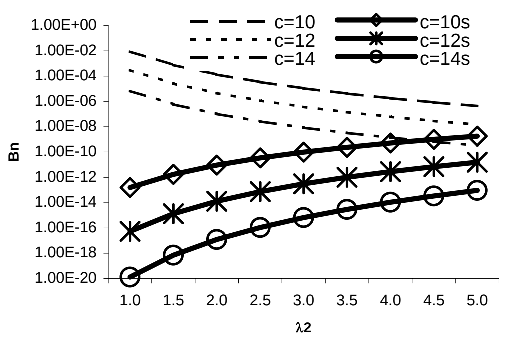
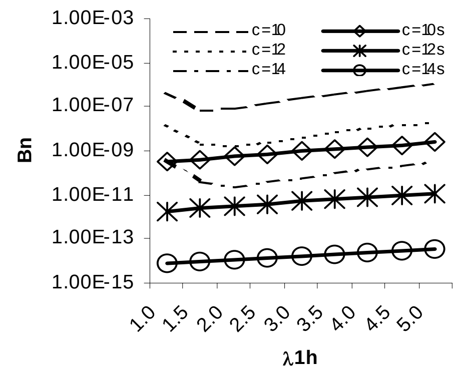
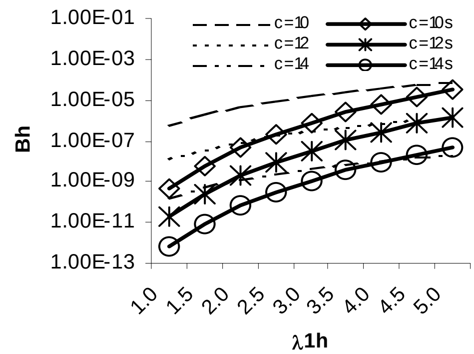


(a)

Fig. 2 : (a),(b),(c): Blocking Probabilities SB and SBF by varying □1



(a)



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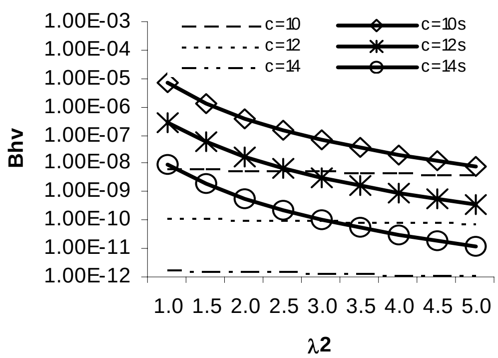

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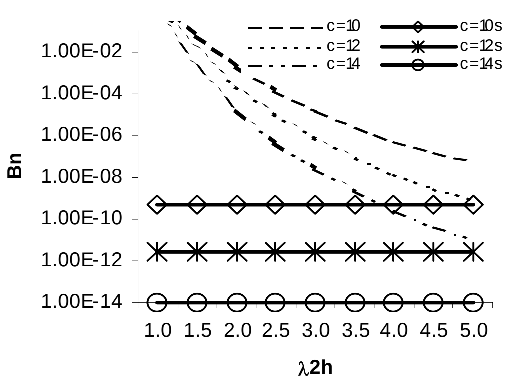
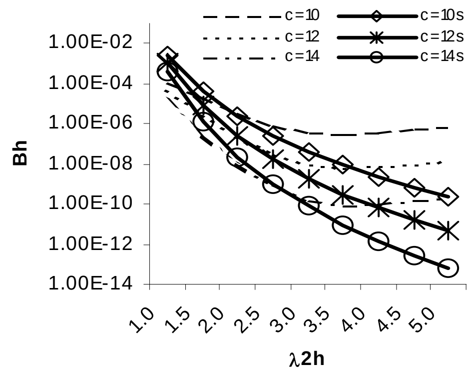
Fig. 3 : (a),(b),(c): Blocking Probabilities SB and SBF by varying □□



(a)



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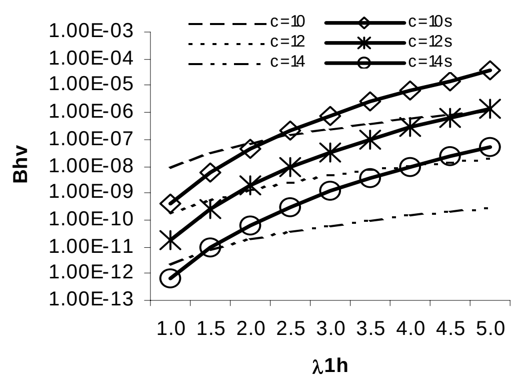

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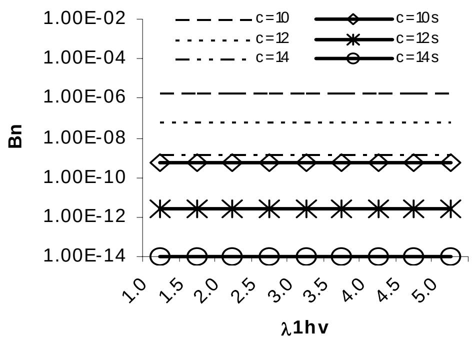
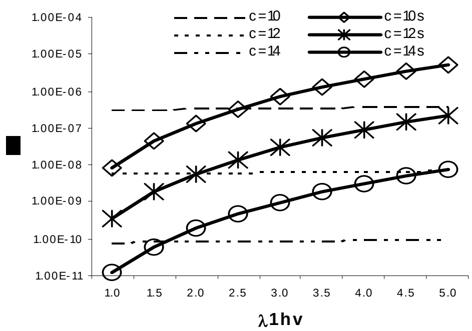
Fig. 4 : (a),(b),(c): Blocking Probabilities for schemes SB and SBF by varying □$_{1h}$



(a)



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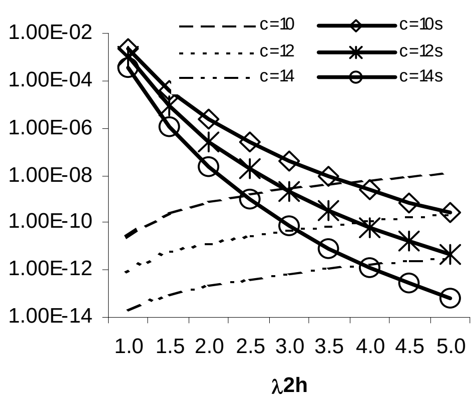

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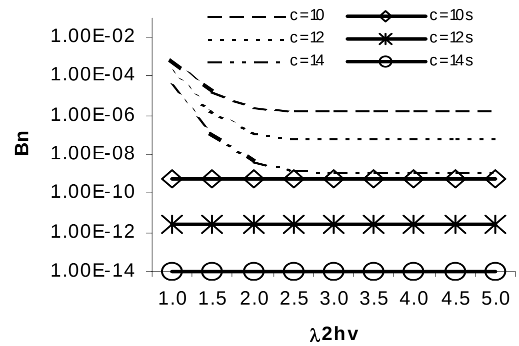
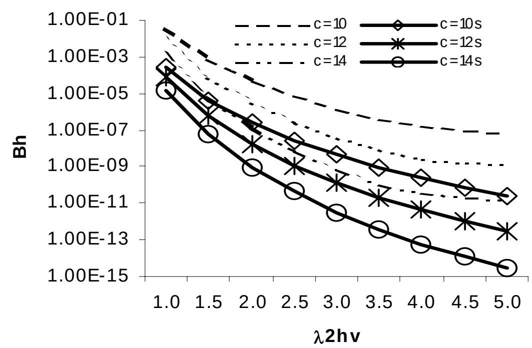
Fig. 5 : (a),(b),(c): Blocking Probabilities for schemes SB and SBF by varying λ_{2h}



(a)



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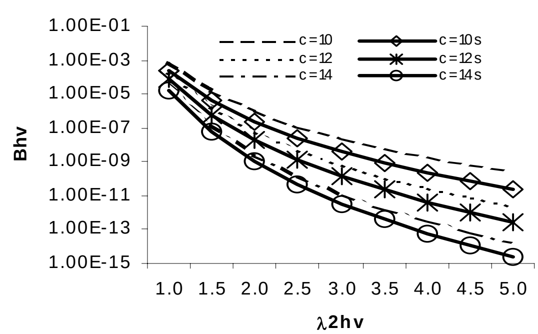
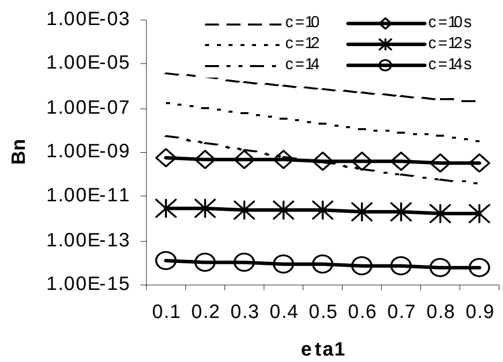
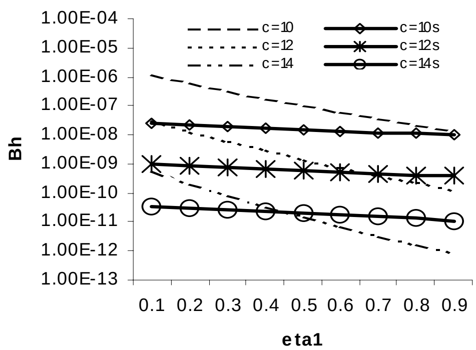


(c)

Fig. 6 : (a),(b),(c): Blocking Probabilities for schemes SB and SBF by varying λ_{1hv}

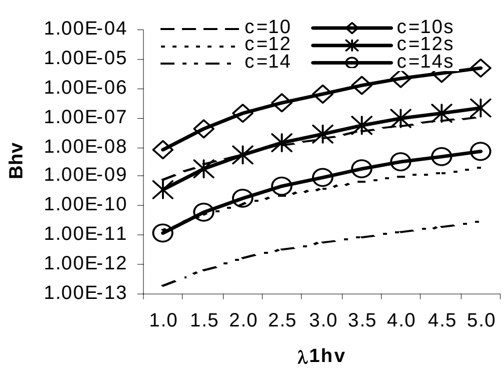


(a)



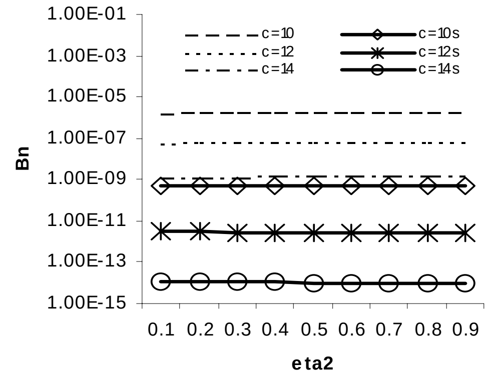
(b)

Fig. 8 : (a),(b),(c): Blocking Probabilities for schemes SB and SBF by varying $\square_1$

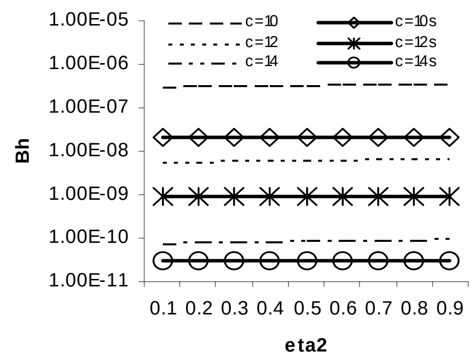


(c)

Fig. 7 : (a),(b),(c): Blocking Probabilities for schemes SB and SBF by varying $\square_{2hv}$



(a)



(b)

Fig. 9 : (a),(b),(c): Blocking Probabilities for schemes SB and SBF by varying $\square_2$

M	M	s	c	B_n	B_h	B_{hv}
5	14	3	6	0.8976	1.95E-02	2.33E-04
	16	5	8	0.9316	0.0082	7.77E-05
	18	7	10	0.9347	0.0041	3.48E-05
	20	9	12	0.9062	0.0022	1.87E-05
	22	11	14	0.8138	0.0012	1.09E-05
	24	13	16	0.5843	5.83E-04	5.64E-06
	26	15	18	0.2522	1.75E-04	1.93E-06
M	M	s	c	Bn	Bh	Bhv
7	14	1	4	0.8339	0.0636	0.0012
	16	3	6	0.8976	0.0195	1.56E-09
	18	5	8	0.9316	0.0082	7.77E-05
	20	7	10	0.9347	0.0041	3.48E-05
	22	9	12	0.9062	0.0022	1.72E-12
	24	11	14	0.8138	0.0012	1.09E-05
	26	13	16	0.5843	5.83E-04	5.64E-06

Table 1: Minblock allocation algorithm by varying M for Scheme SB

□$_1$	Bn	Bh	Bhv	B	CL
1	8.74E-11	1.04E-14	1.92E-17	4.37E-10	9.33E+00
1.50E+00	4.69E-10	2.16E-12	1.33E-14	2.59E-09	1.00E+01
2	1.40E-09	8.61E-11	1.25E-12	8.78E-09	1.07E+01
2.50E+00	3.06E-09	1.39E-09	3.93E-11	2.63E-08	1.14E+01
3	5.92E-09	1.27E-08	6.15E-10	1.03E-07	1.21E+01
3.50E+00	1.41E-08	7.83E-08	5.98E-09	4.97E-07	1.29E+01
4	5.18E-08	3.61E-07	4.09E-08	2.30E-06	1.36E+01
4.50E+00	2.27E-07	1.34E-06	2.14E-07	9.18E-06	1.43E+01
5	9.21E-07	4.17E-06	9.09E-07	3.17E-05	1.50E+01

Table 2 Blocking probability for SB by varying

□2	Bn	Bh	Bhv	B	CL
1.00E-01	9.51E-01	3.80E-22	8.12E-30	6.59E-01	3.41E-01
1.50E-01	4.32E-01	4.40E-21	9.12E-29	2.93E-01	7.07E-01
2.00E-01	7.04E-02	7.15E-21	1.44E-28	4.69E-02	9.53E-01
2.50E-01	1.25E-02	7.54E-21	1.47E-28	8.18E-03	9.92E-01
3.00E-01	2.92E-03	7.55E-21	1.43E-28	1.88E-03	9.98E-01
3.50E-01	8.50E-04	7.51E-21	1.37E-28	5.39E-04	9.99E-01
4.00E-01	2.91E-04	7.46E-21	1.32E-28	1.82E-04	1.00E+00
4.50E-01	1.13E-04	7.41E-21	1.27E-28	6.96E-05	1.00E+00
5.00E-01	4.85E-05	7.36E-21	1.23E-28	2.95E-05	1.00E+00

Table 3 Blocking probability for SB by varying

□1	Bn	Bh	Bhv	B	CL
1	6.09E-05	8.26E-16	8.19E-16	3.05E-04	8.90E+00
1.50E+00	1.78E-03	2.23E-13	2.23E-13	9.77E-03	9.59E+00
2	9.61E-03	5.62E-12	5.62E-12	5.77E-02	1.02E+01
2.50E+00	1.69E-02	3.17E-11	3.17E-11	1.10E-01	1.09E+01
3	2.12E-02	1.01E-10	1.01E-10	1.48E-01	1.15E+01
3.50E+00	2.46E-02	2.55E-10	2.54E-10	1.84E-01	1.22E+01
4	2.78E-02	5.57E-10	5.57E-10	2.22E-01	1.29E+01
4.50E+00	3.10E-02	1.11E-09	1.11E-09	2.63E-01	1.35E+01
5	3.42E-02	2.03E-09	2.03E-09	3.07E-01	1.42E+01

Table 4 Blocking probability for SBF

. □□	**Bn**	**Bh**	**Bhv**	**B**	**CL**
1	**3.07E-07**	**1.23E-09**	**1.23E-09**	**9.23E-07**	**4.59E+00**
1.50E+00	**9.58E-06**	**3.43E-10**	**3.43E-10**	**3.35E-05**	**5.54E+00**
2	**1.03E-04**	**1.36E-10**	**1.36E-10**	**4.12E-04**	**6.49E+00**
2.50E+00	**6.04E-04**	**6.35E-11**	**6.35E-11**	**2.72E-03**	**7.44E+00**
3	**2.27E-03**	**3.10E-11**	**3.10E-11**	**1.13E-02**	**8.38E+00**
3.50E+00	**5.63E-03**	**1.41E-11**	**1.41E-11**	**3.09E-02**	**9.32E+00**
4	**9.61E-03**	**5.62E-12**	**5.62E-12**	**5.77E-02**	**1.02E+01**
4.50E+00	**1.26E-02**	**2.09E-12**	**2.08E-12**	**8.21E-02**	**1.12E+01**
5	**1.44E-02**	**7.78E-13**	**7.77E-13**	**1.01E-01**	**1.21E+01**

Table 5 Blocking probability for SBF

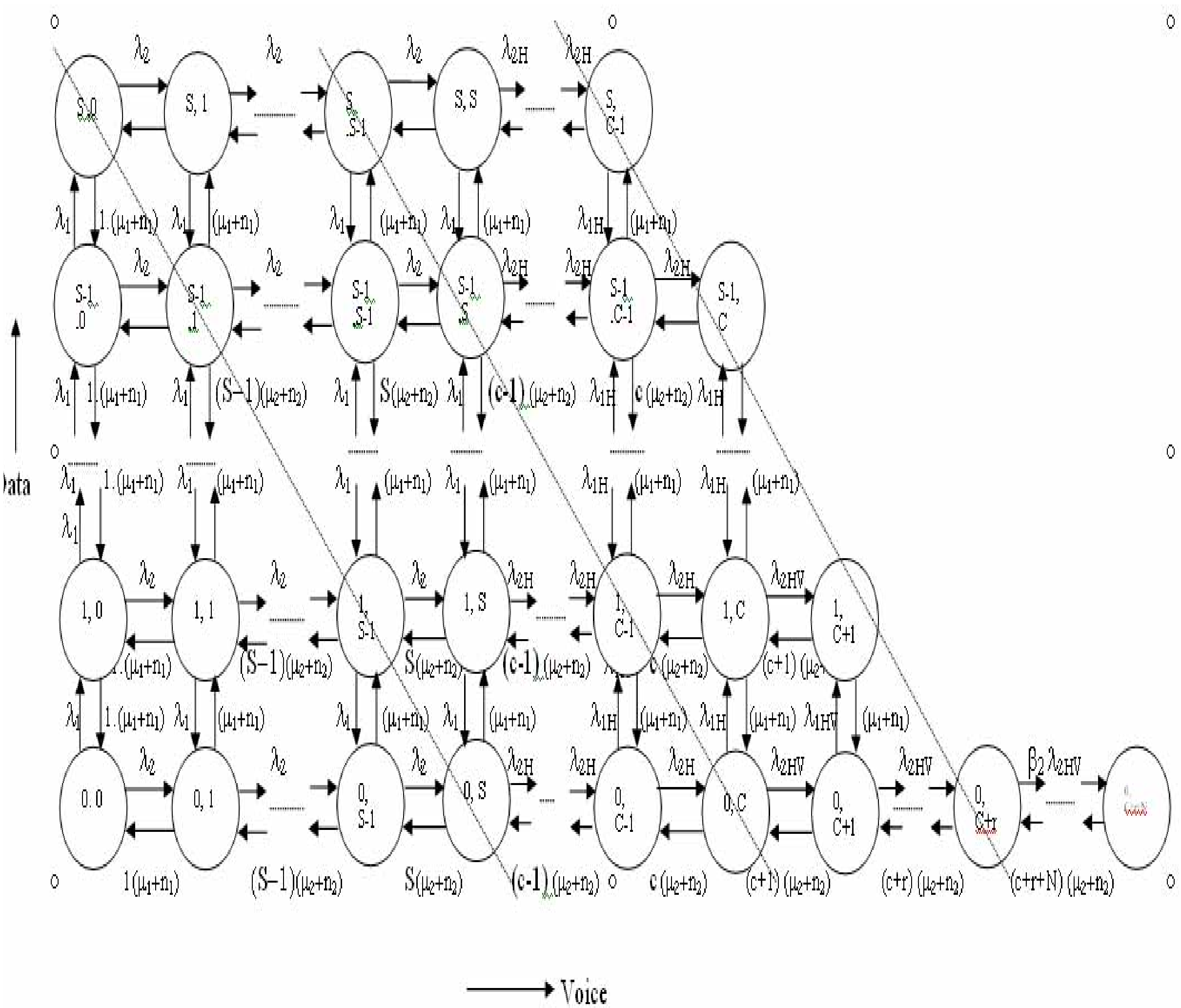


Fig. 1 : State Transition Diagram