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Modeling Prioritized Hard Handoff Management Scheme for Wireless Mobile Networks

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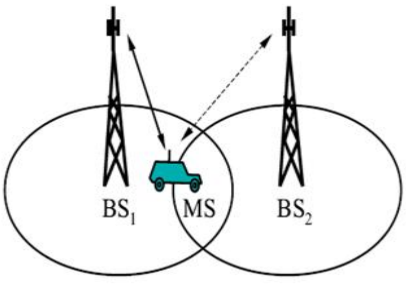
Abstract — The channel associated with the current connection serviced by a *base station* is changed while a call is in progress. Usually, continuous service is achieved by supporting *handoff* from one cell to another. It is often initiated either by crossing a cell boundary or by deterioration in quality of the signal in the current channel. The existing call is then changed to a new *base station*. For the *traffics* which are non stationary at and are away from the servicing *base station*, the chances of a call to be *handed off* are increasing. In this paper we propose a scheme MH_2S to modeling and implementing a *traffic model* with *handoff* behavior for *wireless mobile networks*. The simulation model MH_2S with priority is developed to investigate the performance behavior of *hard handoff* strategy. Novelty of the proposed model MH_2S results that it can improve *call blocking rate of handoff calls*. In addition to this, measurement of blocking probabilities for both *originating calls* and *handoff calls* is another impressive achievement of the model.

Index Terms — Mobile station, traffic model, arrival rate, departure rate, blocking probability, call blocking rate

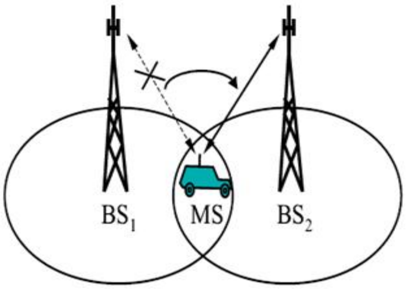
I. INTRODUCTION

At the present time, *traffics* (requests and demands for mobile communication facilities) in the upcoming *wireless mobile networks* (*WMNs*) are expected to be extremely non stationary [1]. The channel associated with the current connection serviced by a *base station* (*BS*) is changed while a call is in progress. Continuous service is achieved by supporting *handoff* [2] from one cell to the next adjacent cell as the *mobile station* (*MS*) moves through the coverage area. The *handoff algorithms* are able to determine the dynamics of the *MSs* which move through the *WMNs* [3][4].

Several competent factors influence to occur a *handoff*. Two of them has more significant effect on it. One, when a *MS* moves across a cell boundary from the servicing BS_1 to another BS_2. Second, deterioration in quality of the signal in the current channel [2][5][6]. The *handoff* phenomena in *WMNs* and mobile cellular communications environment have become progressively more important issue as cell sizes shrink to accommodate an increasingly large *MSs* in terms of demand for services (*traffics*) [7]. In this paper, we present a novel lookup on a *priority handoff. scheme* in a channelized cellular system and *WMNs*. The term *handoff* in this paper refers a *hard handoff*. Another type of *handoff* is the *soft handoff* [2]. How a *hard handoff* is ensured to *MSs* in *WMNs* is shown in Figure 1.



a. Before handoff



b. After handoff

Figure 1. Hard handoff between the MS and BSs.

The Figure 1 shows two cases of the current situations of a MS – before and after *handoffs*. In Figure $1.a$ we see that a MS is serviced by BS_1 and it is moving towards BS_2 without any *handoff* taken place. In the Figure $1.b$ we see that a MS has entered in a *handoff* region. Its services by BS_1 are cut off and are gained by BS_2. Eventually a *handoff* is thus just occurred.

In *hard handoff* the MS is thus *handed off* from its current BS_1 to possible nearest BS_2. At the moment the MSs leave a cell of a the coverage area of the BS_1 and enters into a new cell of the coverage area of the BS_2. In this case, the active set of MSs therefore consists of at most and only one BS at any given time [3].

The decision on the *handoff* to be taken place from one cell to the other is based on various criteria that take into account of channel degradation considerations too [5]. However, the initial (and most important) trigger for a *handoff* is generally based on *pilot signal strength measurements* taken for a MS at the underlying BS. This BS is also known as *mobile terminal* (MT) [8][9]. The S_2BPQ model [8] has taken into account the performance of *handoff* behavior on the basis of *received* or *relative signal strength* (RSS) [5][6][10][11]. The simulated results suggest that a *handoff point* (the maximum allowable radial distance from BS_1 at which MSs possibly gets serviced by another nearest BS_2 instead of its current servicing BS_1) for a MS depends on various parameters that have direct impact on this RSS as determined by Equation (1) in [8][10]. Suppose the radial distance of MSs from a BS (MT) is r. Calls are generally two types – *originating calls*, and *handoff calls*. In this paper we suggest a simulation model MH_2S with *priority handoff scheme* for modeling and implementing a *traffic model*, and evaluating *blocking probabilities* of *originating calls* (B_O), and *handoff calls* (B_H) with the selected *traffic model* [2][8]. All these are performed once we have completed the computation of *arrival rate of handoff calls* (λ_H) of the *traffic model* selected in this paper.

The cellular structure which is considered in all the cases such as S_2BPQ [8], $EATM$ [13], and MH_2S models is shown in Figure 2. This is a well known and well efficient cellular classification of the coverage of a MT and is used in practice. The Figure 2 shows a part of the total cellular configuration (coverage area of a servicing BS). It is actually a segment taken at 120^o orientation of the area.

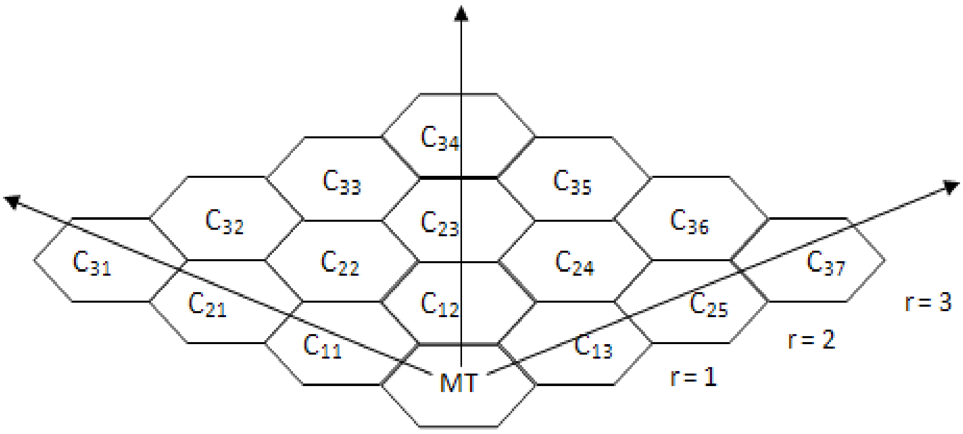


Figure 2. A typical cellular configuration of underlying MT for r = 3.

We organized our paper as follows. First, we start with some preliminary assumptions which have been assumed in Section II. Second, the proposed work has been elucidated in section III. In this section we have selected a *traffic model* followed by modeling it. The model is best suitable for the assumptions would be taken in preceding Section.. We are here able to derive some suitable mathematical expressions for several attributes of the selected *traffic model*. Third, performance of the proposed model MH_2S is appraised with simulation in Section IV. The simulation has been shown both in numerical and corresponding graphical. The paper is over and completed drawing some remarkable conclusions. This has been given in Section V.

II. Preliminaries

We have already known that the RSS measurement is one of the most common criteria to initiate a *handoff* [5][6]. We assumed *two base stations model* in [3][8][11][12] as primary objective of a *handoff algorithm* that provides a good signal quality. We consider only that portion of the trajectory on which the signals received from the two BSs are the strongest. Generally, a high RSS means good signal quality, so the *handoff* to another BS cannot be occurred unnecessary, because the MS is being served well by the current servicing BS and on a *handoff* taken place, all the services must be quit from the current BS. We restrict our analysis to short radial distance r horizons over which a MS moves from one radial distance to another with fixed velocity in any direction (away from current BS, towards BS, or along same radial level from current BS) with equal probability of movement. Movements of MSs in cells are shown in Figure 3 [14]. However, movements of the MSs are unrestricted and random in nature.

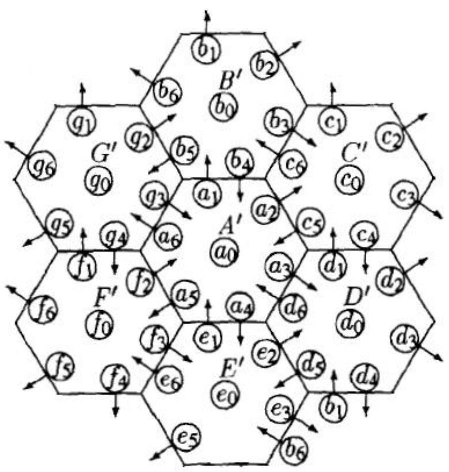


Figure 3. Movements of the MSs.

Although the MSs move randomly in the coverage area. But a *handoff* is only possible as already we know when a MS either crosses a cell boundary merely or its RSS is lower than *threshold* value. Crossing a cell boundary may be possible three ways. First, when MSs move from a cell in radial distance r to a cell at radial distance $(r+1)$. Second, this case is exactly opposite to the previous one. That means MSs in this case move from a cell in radial distance r to a cell at radial distance $(r-1)$. Third, MSs in this case move from a cell to another along the same radial distance r. However, third case is very less responsible for a *handoff* to be happened since RSS of the underlying MTs for MSs remains same. Second case is also less responsible for a *handoff* to be happened since RSS of the underlying MTs for MSs become strengthen since the MSs in this case move towards their servicing MT. The three cases of movements of the MSs have shown graphically. The Figure 4 represents them. Here any node numbered as ij, $i, j \in N$ in Figure 4 represents any cell C_{rj} of the cellular structure shown in Figure 2.

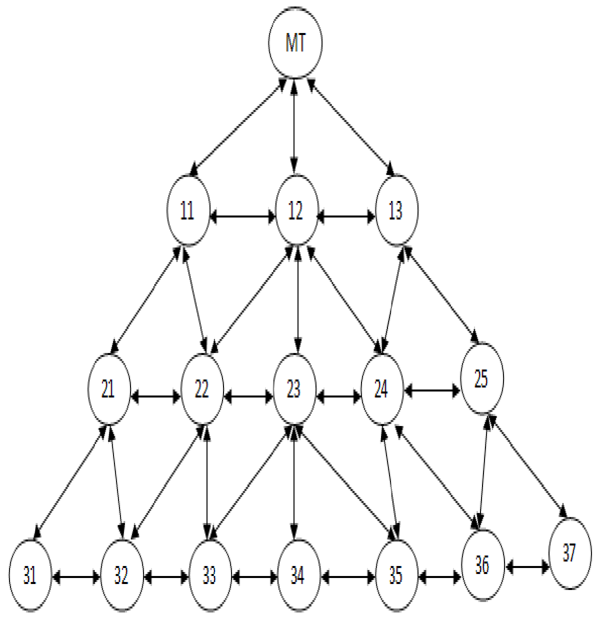


Figure 4. Graphical presentation of movements of MSs.

The MSs also called *mobile callers* (MCs) are evenly distributed over the coverage area of a BS as shown in Figure 3. That means a basic system model assumes that the new call origination rate is uniformly distributed over the mobile service area [2][3][4][5][8][9][10][11][15][16][17]. But it is seen that MSs arrive in a BS randomly. This means requests of MSs are made non-uniformly. We assume these requests are made according to *Poison distributions* [18].

III. Proposed Work

In next-generation wireless systems and $WMNs$ it is important for the MSs to ensure that the system is guaranteeing their needed requirements. These basic requirements would improve the $quality\ of\ service$ (QoS) provided by $WMNs$. Therefore, a proper traffic management scheme is required to effectively manage the ever increasing $traffics\ (MSs)$ which are non stationary at and is on the way away from the servicing BS in the system. There are many proposals to solve the dilemma [1][19]. Our approach provides high precise location and tracking of MSs by exploiting advanced $traffic\ \mathrm{mod}\ els$. Some of these we have studied in [7][8][15][20]. Here we have extended our previous work [8][13] with $El-Dolil\ \ et\ al.'s$ $traffic\ \mathrm{mod}\ el$ [2]. Our proposed model MH_2S takes more advantages over previous model described in [7][8][13][15].

The major functionalities of the proposed model MH_2S have been classified into following sub areas. First, we determine $arrival\ rate\ (\lambda_O)$ of $originating\ calls$. Second, we determine $depurture\ rate\ (\mu)$ of MSs that gets serviced by their servicing BS. Third, we select a suitable $traffic\ \mathrm{mod}\ el$ for implementation. Four, we have chosen a scheme for $handoff$ based on priority. Five, we allocate some channels to $originating\ calls$, $handoff\ \ calls$, and $handoff\ \ requests$. Last, more influencing factor of the model $call\ blocking$ $rate\ (CBR)$ is determined.

A. Determination of λ_O

Number of MSs ($traffic\ density$ [18]) varies location to location. And this location on the contrary affects $arrival\ rate\ \lambda o$ of originating calls from MSs to their underlying BS. Likewise number of BSs are also varied. Assuming distance D [4][17] between nearby two BSs is 1-3 km, λo has been determined here similar to S_2BPQ model [2] [8] as:

$$\lambda o \approx \frac{Total\ \ Subscribers\ \ (S)\ \ in\ the\ \ \mathrm{Re}\,gion}{Total\ \ Number\ of\ \ MTs\ \ (X)} \qquad (1)$$

B. Determination of μ

The model S_2BPQ [8] might be competent of providing services to all (may be infinite number) MSs with no or least waiting time after initiating a call (request for service). Thus, $departure\ \ rate\ \ \mu$ (number of MSs get serviced in unit time) should be at least equal to λo such that waiting time for getting services generally becomes zero or very less. Exploiting $Poison\ \ distributions$ [18], and the traffic intensity factor ρ defined as λ/μ lies in the range $[0-1]$, $departure\ \ rate\ \ \mu$ has been considered similar to S_2BPQ and $EATM$ models [8][13] as:

$$0 \le \rho \le 1 \qquad (2)$$

$$\Rightarrow \quad 0 \le \lambda_O/\mu \le 1 \qquad (3)$$

$$\Rightarrow \quad 0 \le \lambda_O \le \mu \qquad (4)$$

However, μ should be much greater than λ_O so that the MSs get services on their request immediately. Waiting calls are enqueed in a busy list. A call in this list does exist for a little time quanta. When a time quanta is over and the call is not scheduled for services, it is then dropped from the list.

C. Selection of Traffic Model

Every cell in cellular network architecture is served by a BS. The BSs are connected together by using a $wireless\ \ network$. Establishment of a $traffic$ $\mathrm{mod}\ el$, in cellular system, is more imperative before analyzing the performance of the system [7][8]. Several $traffic\ \mathrm{mod}\ els$ [2] have been established on basis of making different assumptions about user mobility. We measure the performance of $handoff\ \ a\lg orithms$ in terms of the $\exp ected\ rate\ of\ handoff\ \ \ (\lambda_H)$. This is one of the parameters used to analyze $handoff$ $performance$ [5][9]. We consider $El-Dolil$ $et\ al.'s\ traffic\ \mathrm{mod}\ el$ [2] which is shown in Equation (5). The selected $traffic\ \mathrm{mod}\ el$ is represented in terms of performance parameter i.e. the $arrival\ \ rate\ \ of\ \ \ handoff\ \ \ calls\ \ \ (\lambda_H)$. The λ_H is then given by:

$$\lambda_H = (R_{cj} + R_{sh})P_{hi} + R_{sh}P_{hh} \qquad (5)$$

Where,

R_{cj} = average rate of total calls carried in cell j.

R_{sh} = the rate of successful $handoffs$.

P_{hi} = the probability that a mobile station needs a $handoff$ in cell i.

P_{hh} = probability that a call that has already been $handed\ off$ successfully would require another $handoff$.

The model has been chosen as underlying implementation model based on some basic assumptions. One, the highway is segmented into cellular structures (microcells) with small BSs. Second, along the highway mobile radio signals that are radiating are cigar-shaped [2][8]. We have derived general mathematical expressions for these parameters of the Equation (5) as follows.

1) Determination of R_{cj}*:* Consider Figure 2 again. At radial distance $r=1$ from servicing BS (MT), number of cells is 3. In the same fashion at r = 2, 3… $R_{\max}$ number of cells are 5, 7… $(2\times R_{\max}+1)$ respectively. Thus, $R_{\max}$ represents maximum radial distance or $handoff\ point$ [8]. In general, total cells N under the coverage area of a typical BS is given by:

$$N=\sum_{r=1}^{R_{\max}}(2r+1) \quad (6)$$

However $traffic\ density$ is not uniform. For better services, a BS should have some number of MSs to make it busy and the BS should not be overloaded some time. Although this not the actual cases. Because a BS may be overloaded some time or may goes down with performances. Average number of MSs, $Subs$ in any cell j at any r from its BS (represented as C_{rj}) is obtained as:

$$Subs=\frac{Total\ \ Number\ of\ \ MSs\ \ (S)}{Total\ \ Number\ of\ \ Cells\ \ (N)} \quad (7)$$

The $Subs$ are not actually MSs rather they are meant by the MSs who have already made requests. The MSs are allowed making any number of requests.

Let us assume a term that an average number of calls (requests) originated by $subscriber\ (MS)$ is $calls\ \ per\ day\ \ per\ \ subscriber\ \ (CPD)$. Thus R_{cj} can be determined at any particular radial distance j from the current BS as:

$$R_{cj}=\prod(Subs,CPD,(2j+1)),\ j=1,2...R_{\max} \quad (8)$$

2) Determination of R_{sh}*:* The MSs are non stationary. When a MS is moving away from its BS, its RSS value is decreasing. Therefore, a MS has a chance to be $handed\ off$ and probably is $handed\ off$ from serving BS_1 to another BS_2 when this RSS value gets decreased below at least 50% of its original strength value [8]. The RSS is sampled at discrete time instants $t_j=kt_s$, where t_s is sampling time and corresponding sampling interval in distance is $d_s=vt_s$. . Here, v is constant velocity of a MS [12]. Thus, at the radial distance $R_{\max}$ from the current BS, a $handoff$ for the MS occurs first time. However, before a call (MS) is $handed\ over$ from BS_1 to another BS_2 it has to travel a radial level $R_{\max}$. Therefore, $Subs$ are gradually increased when MSs move to r from $(r+1)$.

We assume for simplicity that two-third movement of the MSs take place to immediate upper radial level from current radial level. Few of them may come back to their starting radial distance. Therefore total number of MSs moved away from their BS are effectively less, We assume that one-third of the MSs move back to its immediate lower radial level from current radial level. These movements are applicable to all the radial level. Thus, taking effect of both $in-just$ upper and lower radial levels, R_{sh} at any level r from its nearest BS has been determined in Equation (9) as:

$$R_{sh}=\begin{cases}\prod\left(\left(\frac{2}{3}(2r+1)+\frac{1}{3}(2j+1)\right),Subs\right), & r=1,\ \ j=r+1\\ \prod\left(\left(\frac{1}{3}(2i+1)+\frac{2}{3}(2r+1)+\frac{1}{3}(2k+1)\right),Subs\right), & r=2,\ 3.....R_{\max},\ \ i=r-1,\ \ k=r\end{cases} \quad (9)$$

3) Determination of P_{hi}: Movements of the MSs are either towards or away from current serving BS and are primarily responsible for $handoff$ mechanism to be taken place. Every MS has same opportunity to be $handed\ over$. Let us choose any $mobile\ station\ MS_r$ at any radial distance r, $1 \le r \le R_{max}$ from its underlying BS. Therefore, the probability of selection of MS_r could be represented as:

$$P(MS_r) = \frac{1}{2r + 1 + \delta} \qquad (10)$$

Where δ = a constant factor assumed as the effect of adjacent cells (left and right most) at any r.

We consider the value of δ equals to 2 when a MS moves towards BS_1 and 0 when it moves towards BS_2. The $P(MS_r)$ can be computed in two ways. One, $in-ward\ handoff\ probability\ P_{h_i}(\downarrow)$ in a cell i. Second, $out-ward\ handoff\ probability\ P_{h_i}(\uparrow)$ in a cell i. These names are given according to the movements of MSs. The $P_{h_i}(\downarrow)$ is likely to be happened when MSs move towards their servicing BS. And, the $P_{h_i}(\uparrow)$ is likely to be happened when the MSs move away from their servicing BS. Here, both $P_{h_i}(\downarrow)$, and $P_{h_i}(\uparrow)$ are $inter-level\ handoff\ probabilities$. However, an actual $handoff$ for a MS takes place at $r = R_{max}$. Another interesting thing is that the probability $P_{h_i}(\downarrow)$ decreases the chances of $handoff$ to be occurred till $r \ge 1$ while the probability $P_{h_i}(\uparrow)$ enhances the chances of $handoff$ to be occurred till $r \le R_{max}$. Assuming initial values of $P_{h_i}(\downarrow)$, and $P_{h_i}(\uparrow)$ are zero, We compute them as:

$$P_{h_i}(\downarrow) = \frac{1}{3}\sum_r \left(P_{h_{i+1}}(\downarrow) + \frac{1}{2i+3} \right), i = R_{max} \ldots 2,1 \qquad (11)$$

And,

$$P_{h_i}(\uparrow) = \frac{1}{3}\sum_r \left(P_{h_{i-1}}(\uparrow) + \frac{1}{2i+1} \right), i = 1,2 \ldots R_{max} \qquad (12)$$

Now, a $handoff\ point$ (the maximum radial distance of a MS from its servicing BS) is at $r \le R_{max}$. Before reaching a MS to a $handoff\ point$ it may have either $P_{h_i}(\downarrow)$ or $P_{h_i}(\uparrow)$. Therefore, at any level $r,\ 1 \le r \le R_{max}$, the probability P_{hi} that a MS needs a $handoff$ in cell i can thus be urged as below.

$$P_{hi} = 1 - \left(P_{h_i}(\uparrow) + P_{h_i}(\downarrow) \right), r = 1,2 \ldots R_{max} \qquad (13)$$

4) Determination of P_{hh}: We have exploited the property that two-third of the MSs at radial level r move to immediate upper level $(r+1)$ and one-third of the MSs at radial level r move to immediate lower level $(r-1)$. Some of the MSs under BS_1 at the $handof\ point$ may move to $(R_{max}+1)$ which is similar to R_{max} from BS_2. Second $handoff$ may occur when MSs eventually come back to R_{max} with respect to BS_1. Therefore, the probability of $next\ handoff\ P_{hh}$ of a MS may be determined as –

$$P_{hh} = \frac{1}{3}\left(\frac{2}{3}\sum_{r=1}^{R_{max}} \frac{1}{3^r} + \frac{1}{3^{R_{max}}} \right) \qquad (14)$$

D. Priority Handoff Scheme

A $handoff\ request$ is generated in a cell when a MS approaches the cell from a neighboring cell with significant signal strength. Priority is set to $handoff\ requests$ and their types. Some channels are necessarily assigned in a cell. These assigned channels may be exclusive or shared. Suppose, S_R channels have been assigned exclusively for $handoff\ calls$ out of S channels . And, both $originating\ calls$ and $handoff\ requests$ share the remaining $S_c = S - S_R$ channels. An $originating\ call$ call is blocked if the number of available channels in the cell is less than or equal to S_R. Similarly a $handoff\ request$ is blocked if no channel is available in the target cell. The system model for the channels sharing is shown in Figure 5 [2][7].

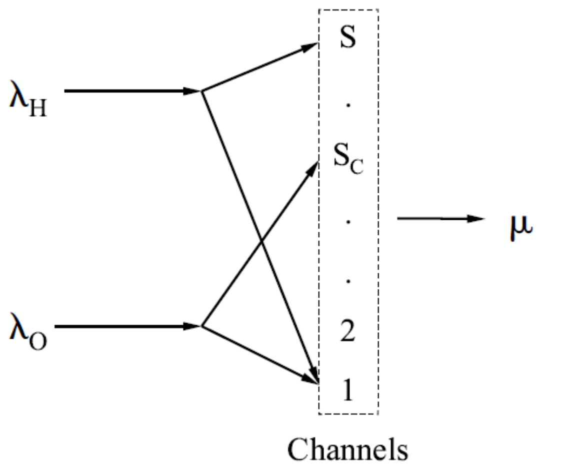


Figure 5. System model with priority for handoff call.

Two important parameters can be derived from this allocation of channels. These are *blocking probabilities* B_O of *originating calls*, and B_H of *handoff requests* [2][7][8] respectively. They have been determined by Equations (15), and (16) with the steady-state probability $P(i)$ [2] respectively.

$$B_O = \sum_{i=S_C}^{S} P(i) \qquad (15)$$

And,

$$B_H = \frac{(\lambda_O + \lambda_H)^{S_C} \lambda_H^{S-S_C}}{S!\,\mu^S} P(0) \qquad (16)$$

Here $P(0)$ [2][7] states steady state probability when the system is in state "0". We define the state i, $i = 0,1,2......S$ of a cell as the number of calls in progress for the BS of that cell.

E. Channel Allocation Scheme

A new call holds the channel until the call is completed in the cell or it move out of the cell. A successful *handoff call* holds the channel until the call is completed in that cell. Thus, *handoff call* is admitted until all channels are busy [21]. In the evaluation of *handover (handoff) performance*, number of channels to be allocated for *handoff requests*, and *originating calls* are exclusively important very much along with other factors such as RSS, R_{max} etc [2][22]. Already we have seen that how some channels S are necessarily assigned in a cell for *handoff calls*, *handoff requests*, and *originating calls*. Although all the channel allocation schemes are facing the same challenge that how the channels could be distributed (allocated) effectively to these calls. Because the amount of channels in terms of *frequency ranges* is fixed.

F. Determination of Call Blocking Rate

A MS when initiates a call, it generally expects to be get serviced immediately. Types of requests are different. Before a request gets serviced, it must be enqueed in *priority queue* [8][23]. Afterward a call gets serviced by its current MT (BS_1) taking advantage of *Splay operations* on the *Splay Tree* [24] implementation of the *priority queue* generated in [8]. The selection of a call in the *Splay Tree*, follows *SIRO queuing principle* [18]. So, more and more number of cells are getting services in a cell. At particular radial level r, $r = 1, 2....R_{max}$ and a specific time instant, number of calls blocked (enqueed) for availing services i.e. *call blocking rate* (CBR_r) [25] could be decided as:

$$CBR_r = \frac{1}{3}\prod\left(R_{cj_r} \;,\; B_O \;,\; (2r+1)\right) \qquad (17)$$

We will show that this CBR_r, $r = 1, 2....R_{max}$ will be increasing with r increases.

IV. Simulation Work

The parameters used for simulation are commonly used to analyze *handoff performances*. We simulated our model MH_2S in MATLAB Version 7.6.0.324 (R2008A). Numerical values of the fundamental parameters for *handover initiations*, λ_o, and μ are based on COAI REPORT [26][27] developed for beloved Megacity Kolkata. These parameters are set as λ_o = 1991, and μ = 2212 [8]. Exploiting these numerical on all the Equations (5) through (17) whenever necessary are assessed. Here we have shown two observations. We assume that the shadow fading effect ζ (r) is log(r) in all the observations.

Observation I: Let us suppose that a MC makes at least 5 requests per day (CPD). We assumed Є = 0, and η = 20 in Equation (1) [8] and we found R_{max} = 14. Using Equation (6) and Equation (7), total number of cells N and average number of MSs in any cell $Subs$ are found 224 and 2.9632 respectively. Other values are shown in Table I.

Table I: Simulation of MH_2S for CPD = 5.

Parameters	Numerical Outcomes Under Current Base Station Level Wise		
R_{cj}	44.44742	74.07904	103.7107
	133.3423	162.9739	192.6055
	222.2371	251.8687	281.5004
	311.132	340.7636	370.3952
	400.0268	429.6584	
R_{sh}	10.86493	19.75441	27.65617
	35.55794	43.4597	51.36147
	59.26323	67.165	75.06676
	82.96852	90.87029	98.77205
	106.6738	114.5756	
P_{hi}	0.80067	0.83163	0.86666
	0.89321	0.91206	0.92555
	0.93549	0.94306	0.94903
	0.95388	0.95797	0.96166
	0.96559	0.97131	
P_{hh}		0.11111	
λ_H	28.09555	47.37267	68.98609
	91.29296	113.8331	136.4347
	159.0444	181.6503	204.2531
	226.8593	249.4859	272.1833
	295.1101	318.7731	
λ_O		22.8851	
μ		25.4278	
B_O		0.75684	
B_H	0.089776	0.12517	0.17025
	0.21778	0.26604	0.31441
	0.36272	0.41096	0.45914
	0.50731	0.55555	0.60407
	0.65355	0.70618	
CBR_r	33.639646	93.44346	183.14918
	302.75681	452.26635	631.67779
	840.99114	1080.2064	1349.3236
	1648.3426	1977.2636	2336.0865
	2724.8113	3143.438	

The graphical representations of the parameters λ_H, B_O, B_H, and CBR_r produced in Table I for Observation I , have been shown in the Figures 6 though 9 respectively.

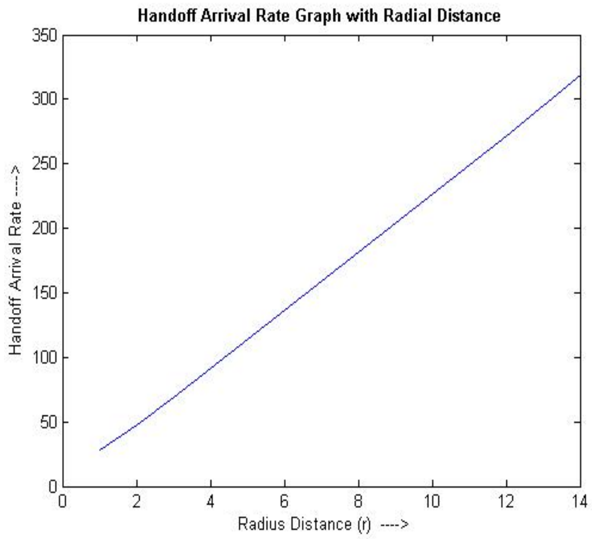


Figure 6. Arrival rate of handoff requests.

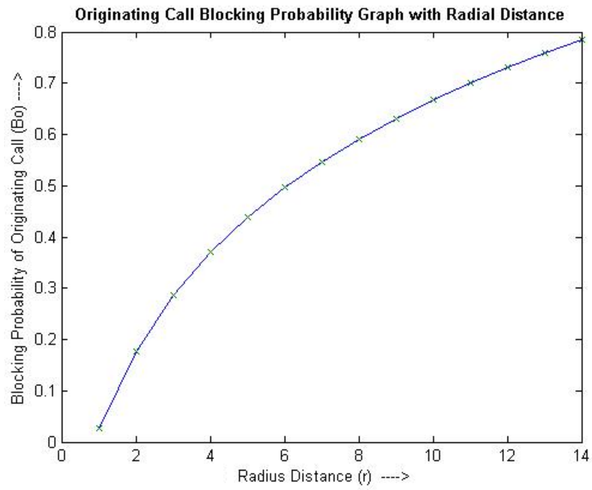


Figure 7. Growth of B_O for originating calls.

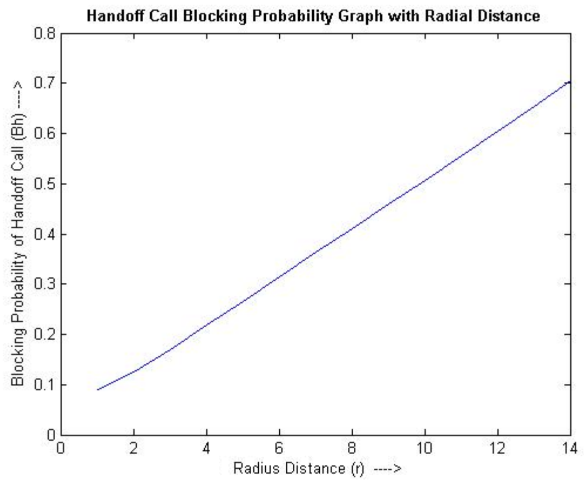


Figure 8. Growth of B_H for handoff calls.

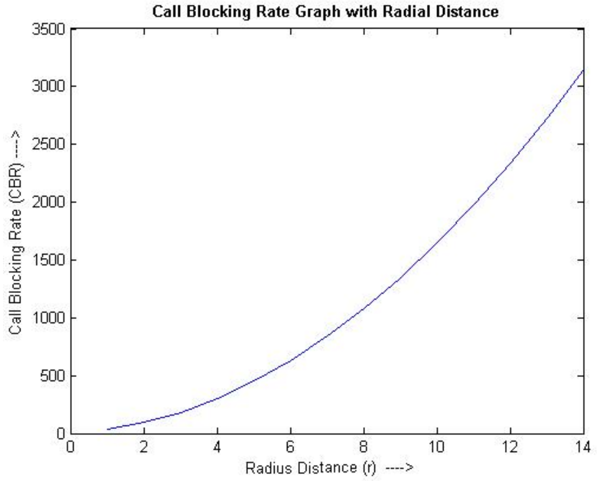


Figure 9. Growth of call blocking rate.

Observation II: Let us suppose that a MC makes at least 6 requests per day (CPD). In the same way (simulation made in Observation I) assuming Є = 0, and η = 21 in Equation (1) [8], we get $R_{\max} = 12$. Similarly N and $Subs$ are obtained as 168 and 3.9509 respectively from Equation (6) and Equation (7) respectively. Other values are shown in Table II.

Similarly, the graphical representations of the parameters λ_H, B_O, B_H, and CBR_r produced in Table II for this Observation II , have been shown in the Figures 10 though 13 respectively. First we showed Figure 10 which represents the parameter λ_H. Other Figures 11 through 13 have been shown after Table II.

The CPD values are increased in both the observations by 1. Other higher values could be assigned to CPD . However, in general it is seen that CPD values are not changed suddenly. These values are based on the statistics collected from certain percentage of general people.

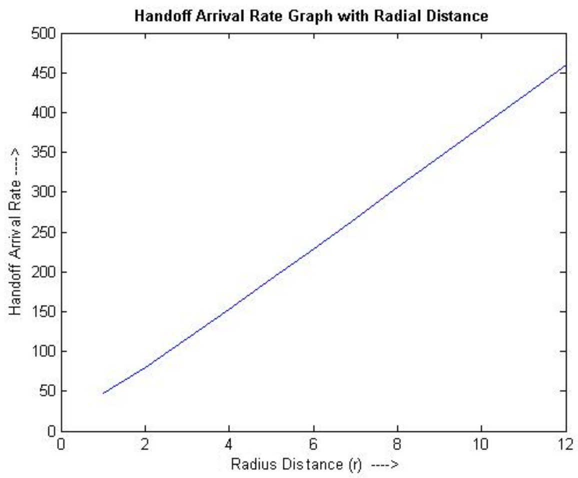


Figure 10. Arrival Rate of handoff requests.

Table II: Simulation of MH_2S for CPD = 6.

Parameters	Numerical Outcomes Under Current Base Station		
R_{cj}	71.11588	118.5265	165.937
	213.3476	260.7582	308.1688
	355.5794	402.99	450.4006
	497.8111	545.2217	592.6323
R_{sh}	14.48657	26.33921	36.8749
	47.41059	57.94627	68.48196
	79.01764	89.55333	100.089
	110.6247	121.1604	131.6961
P_{hi}	0.80067	0.83163	0.86666
	0.89321	0.91206	0.92555
	0.93551	0.94313	0.94922
	0.95444	0.95964	0.96668
P_{hh}		0.11111	
λ_H	46.95075	79.59185	115.9499
	153.4849	191.4158	229.4519
	267.5049	305.5608	343.6436
	381.8374	420.4091	460.2128
λ_O		26.5467	
μ		29.4963	
B_O	0.032694	0.19616	0.31293
	0.40374	0.47805	0.54092
	0.59541	0.64349	0.68651
	0.72543	0.76097	0.79366
B_H	0.12074	0.17735	0.24776
	0.32228	0.39813	0.47429
	0.55046	0.6266	0.70281
	0.77945	0.85757	0.94058
CBR_r	58.126376	161.46216	316.46583
	523.13739	781.47684	1091.4842
	1453.1594	1866.5025	2331.5135
	2848.1924	3416.5392	4036.5539

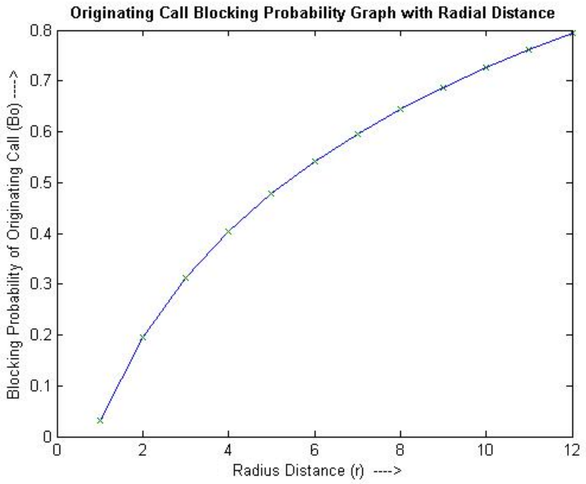


Figure 11. Growth of B_O for originating calls.

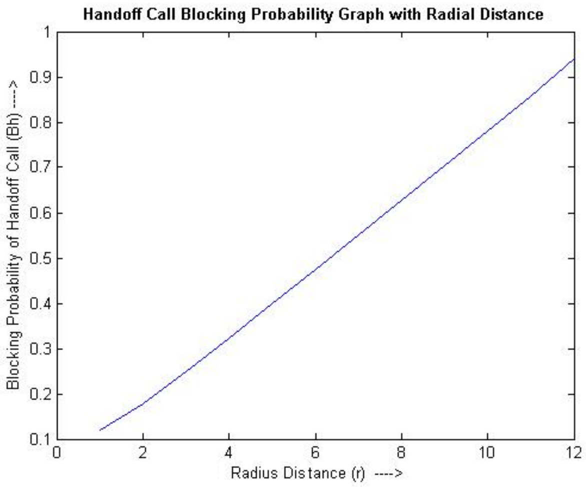


Figure 12. Growth of B_H for handoff calls.

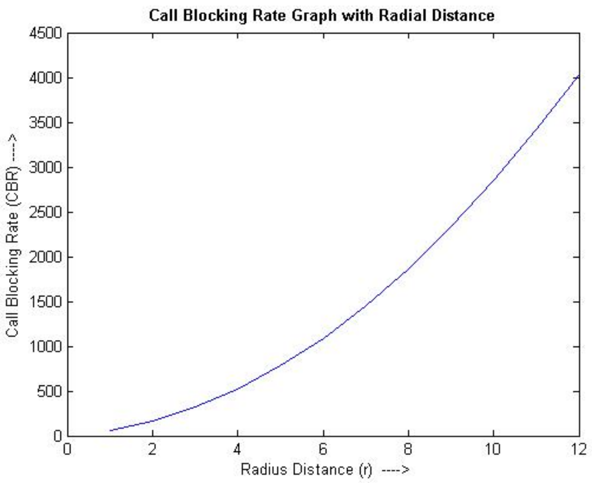


Figure 13. Growth of call blocking rate.

V. Conclusions

To the best of our knowledge, it is the first time that an explicit mathematical derivations have been proposed to calculate $arrival\ \ rate\ \ of\ \ handoff\ \ calls\ \lambda_H$ when the MSs are mobile. We are able to present an easy method that evaluates priority scheme on selection of a suitable $traffic\ \mathrm{mod}\ el$ analytically. Simulation results show that our algorithm performs better than some existing $handoff\ \ a\lg orithms$. The proposed model MH_2S can achieve satisfactory number of $handoffs$ taken place on an average. Compared with other $handoff\ \ a\lg orithms$, the only overhead of the proposed algorithm is proper allocation of channels. Therefore, our algorithm can improve $handoff\ \ performance$ effectively at the cost of very marginal overhead comparatively with less number of channels. It is observed that increasing average number of calls per MSs per day i.e. CPD helps to improve the B_O for both $handoff\ \ requests$, and $originating\ \ calls$. And these values are nearer to their actual values. Another achievement of the proposed model is working out of $rate\ \ of\ \ blocked\ \ calls\ \ (CBR)$ in addition.

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References

[1] N. Mohan, T. Ravichandran, "An Efficient Multiclass Call Admission Control and Adaptive Scheduling for WCDMA Wireless Network", European Journal of Scientific Research, Vol. 33 No. 4, 2009, Pp.718-727.

[2] Ivan Stojmenovic, Qing-an Zeng and Dharma P. Agrawal, *Handbook of Wireless Networks and Mobile Computing*, John Wiley & Sons, Chapter 1, 2002.

[3] Alexe E. Leu, Brian L. Mark, "A Discrete-Time Approach to Analyze Hard Handoff Performance in Cellular Networks", IEEE Transactions on Wireless Communications, Vol. 3, No. 5, 2004, Pp: 1721 – 1733.

[4] S. A. Mawjoud, "Simulation of Handoff Techniques in Mobile Cellular Networks", Al-Rafidain Engineering ,Vol. 15 No.4, 2007, Pp: 31 – 39.

[5] Huamin Zhu and Kyung Sup Kwak, "An Adaptive Hard Handoff Algorithm for Mobile Cellular Communication Systems", ETRI Journal, Volume 28, Number 5, October 2006, Pp: 676 – 679.

[6] Sanjay Dhar Roy, "A Timer based Handoff Algorithm for Multi-cellular Systems", ICETET 2008, IEEE, Pp: 819 – 822.

[7] Biswajit Bhowmik, Smita Roy, Parag Kumar Guha Thakurta, Arnab Sarkar, "Priority Based Hard Handoff Management Scheme for Minimizing Congestion Control in Single Traffic Wireless Mobile Networks", International Journal of Advancements in Technology, Vol. 2(1), 2011, Pp: 90-99.

[8] Biswajit Bhowmik, Pooja, Piyali Sarkar, Nupur Thakur, "Received Signal Strength Based Effective Call Scheduling in Wireless Mobile Network", International Journal of Advancements in Technology, Vol. 2(2), 2011, Pp: 292 – 305.

[9] Rajat Prakash, Venugopal V. Veeravalli, "Adaptive Hard Handoff Algorithms", Proc. VTC'99, Houston, TX, May 99.

[10] Mohmmad Anas, Francesco D. Calabrese, Preben E. Mogensen, Claudio Rosa, Klaus I. Pedersen, "Performance Evaluation of Received Signal Strength Based Hard Handover for UTRAN LTE", IEEE Vehicular Technology Conference, April 2007, Pp:1046 – 1050.

[11] Venugopal V. Veeravalli, Owen E. Kelly, "A Locally optimal handoff algorithm for cellular communications", IEEE Trans. on Vehicular Technology, 1997, Pp: 1 – 8.

[12] Sanjay Dhar Roy, "Performance Analysis of Handoff Algorithms for Multihop Ad Hoc Wireless Network", ICETET 2008, IEEE, Pp: 157 – 161.

[13] Biswajit Bhowmik, Pooja, Nupur Thakur, Piyali Sarkar, "Experimental Analysis of Xie and Kuek's Traffic Model with Handoff Scheme in Wireless Networks", *Int. J. of Information Engineering and Electronic Business*, Vol. 4, No. 1, 2012, Pp: 34-43.

[14] Hua Jiang and Stephen S. Rappaport, "Hand-Off Analysis for CBWL Schemes in Cellular Communications", CEAS Technical Report, No. 683, 1993.

[15] Biswajit Bhowmik, Arnab Sarkar, Parag Kumar Guha Thakurta, "Simulation of Handoff Management Scheme for Improved Priority Based Call Scheduling with a Single Traffic System in Mobile Network", Int. J. of Advanced Research in Computer Science", Vol. 1(3), 2010, Pp: 354-358.

[16] Biswajit Bhowmik, *Design and Analysis of Algorithms*, S.K. Kataria & Sons, Second Edition, 2012.

[17] Raymond M. Bendett and Perambur S. Neelakanta, "Alternative Metrics for Hard Handoffs in Mobile Communication", ICPWC 2000, IEEE, 2000, Pp: 43 – 46.

[18] J K Sharma, *Operations Research - Theory and Application*, Macmillan Publishers, 3/e, 2006.

[19] Azita Laily Yusof, Mahamod Ismail, Norbahiah Misran, "Traffic Management Algorithm and Adaptive Handover Initiation Time for Dynamic Traffic Load Distribution", IJCSNS International Journal of Computer Science and Network Security, Vol 8 No7, 2008, Pp: 203 – 207.

[20] Marco Anisetti, Claudio A. Ardagna, Valerio Bellandi Ernesto Damiani, Salvatore Reale, "Advanced Localization of Mobile Terminal in Cellular Network", I. J. Communications, Network and System Sciences, Vol 1, 2008, Pp: 95 – 103.

[21] Nguyen Cao Phuong, Sang-Ho Lee, Jung-Mo Moon, Tran Hong Quan, "Priority-based Call Admission Control of multiclasses in Mobile networks", ICA0T2006, IEEE Xplore, Feb. 20-22, 2006,Pp: 1471 – 1474.

[22] Hsin-Piao Lin, Rong-Terng Juang, and Ding-Bing Lin, "Improved Location-Based Handover Algorithm for Mobile Cellular Systems with Verification of GSM Measurements Data", IEEE Trans. on Vehicular Technology, 2002, Pp: 5170 – 5174.

[23] Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, "*Introduction to Algorithms*, PHI, 2nd Edition, 2006.

[24] D. Samanta, *Classic Data Structures*, PHI, 2nd Edition, 18th printing, 2010.

[25] P. K. Guha Thakurta, Souvik Sonar, Biswajit Bhowmik, Swapan Bhattacharya, Subhansu Bandyopadhyay, "A New Approach on Priority Queue based Scheduling with Handoff Management for Mobile Networks", 19th Int. Conf. on SEDE, ISCA, 2010, Pp: 69 – 74.

[26] http://www.coai.com/study_papers.php?val=2010

[27] http://en.wikipedia.org/wiki/Kolkata#Geography.

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