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Performance Evaluation of Handoff Call Arrival Rate in Microcell of GSM Networks by Hong and Rappaport Traffic Model

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***Abstract**: The handoff process is the main issue that associated with the unavailability of bandwidth when the subscriber moves from the serving cell to another new one with the new frequency and other different parameters. In turn, the handoff failure results in call drop and block. Therefore, it will probably affect the overall network performance negatively. So, other precaution has to be made for reducing the both call drop and block. In this paper, the mathematical Hong and Rappaport traffic model is carried out to evaluate the handoff calls arrival rate in microcell of the wireless network. It gives good results concerning the most affecting parameters that are positively and negatively affect the system performance. It is found that, the probability of a new call that is not blocked (P_h), the probability that a call been handoff successfully (P_{hh}), and handoff arrival rate of anew calls (λo) are all directly assist in increasing the handoff calls arrival rate as they increase linearly . On the other hand , both the blocking probability (Bo) and the probability of handoff failure (Pf) are all affect the handoff calls arrival rate inversely. As they increase they will assist in decreasing the handoff calls arrival rate probability.*

Keywords: Handoff call rate, system performance, cell phone.

1. Introduction

In the previous mobile generations such as first and second, the main technique that is used is the circuit switching. The circuit switching support both voice and low data rate traffic such as short message service (SMS). In the third generation, the traffic is beginning to increase significantly because of deployment of IP- services so that the subscribers utilized their wireless devices most of time in different applications. The main characteristics of GSM systems offer subscribers maximum freedom of movement while using mobile phones [1]. GSM networks provide services to their subscriber in the coverage area. Such areas are populated with base stations each of which is responsible for relaying communication services for the mobile phone moving within it is coverage called cell [4]. Normally, the wireless communication systems cover the non-densely populated area with the small cells especially in the urban for low cell capacity and minimum power consumption [4, 3]. The related small cells that is used in this paper; it is microcell. The cells are the basic elements in the GSM architecture where the bands of frequencies are allocated [5]. Adjacent cells are assigned different frequencies to avoid interference or cross talk. Since the GSM system has to cover a wide geographical area by multi-different cells [5], there are no extra enough radio frequency bands to be used. So, the same frequency bands will be reused in different area for a quite different transmission in order to maximize the system capacity [2, 6]. The reuse of frequency bands can be assigned to the parted cells to help in controlling both the location management and mobility management. As the subscriber habitually move from one certain assigned frequency cell to another different one, the system is required to assign him the same frequency to assist in ensuring his continuous call [5]. Otherwise, the moving subscriber that began to lose the serving cell signal and in the same time receiving the stronger signal from the cell that he moves to. The handoff process will probably begin to take place to provide the moving subscriber with the same call quality of service. The handoff decision in most cases may be supported by important different parameters such as bandwidth, signal to inference ratio, received signal strength, cost, latency, security, velocity, and battery power, service capacities and quality of service (QoS) [3]. If the next target cell has no available bandwidth or empty channels, the target cell will not accept the handoff call request. As a result, the handoff call request will be dropped, and in the same time if there are other initiate calls in the target cell, they will definitely block [8]. Both the dropped and blocked calls affect the system performance.

2. Mathematical Hong and Rappaport Traffic Model

The mathematical model is used in analyzing the system performance under multi different conditions to evaluate the handoff calls arrival rate. The model is depending on different fundamental parameters to assist in calculating the probability of handoff calls arrive rate. Hong and Rappaport traffic model is proposed for hexagonal cells and assume that the user is in the vehicle which is moving within the service area of the cell. So the location of the vehicle when call initiated is uniformly distributed in the cell. It also assumed that the vehicle initiating a call move from the current location in any direction in the cell. Accordingly, the model is recast to evaluate the handoff arrival calls rate as:

$$\lambda_H = \frac{Ph(1-Bo)}{1-Phh(1-Pf)}\lambda_O \qquad (1)$$

Where: P_h: the probability that a new call that is not blocked would require at least one handoff, P_{hh}: the probability that a call that has already been handed off successfully would require another handoff, *Bo*: the blocking probability of originating calls, *Pf*: the probability of handoff failure, λo: the arrival rate of originating calls in a cell [5]. The system parameters that are calculated at the microcell are varied in wide different ranges. Accordingly, theses ranges are dynamic but other parameters remain constant for some period of time. So, these changes can make the system classified into different cases. Each case can be characterized with different changed parameters. Therefore, the system performance will also definitely be changed. The Hong and Rappaport mathematical traffic model is carried out to give overall evaluation of the system performance at the microcell. Each case with its changed parameter is clearly shown in table1.

Table1 the constant and inconstant parameters in all cases

	Case 1	**Case 2**	**Case 3**	**Case 4**	**Case 5**
Parameter	Probability	Probability	Probability	Probability	Probability
Bo	0.01	0.01	**0.005 – 0.02**	0.01	0.01
λo	0.87	0.87	0.87	0.87	**0.68 - 0.96**
Pf	0.02	0.02	0.02	**0.015 – 0.029**	0.02
Ph	**0.70 – 0.98**	0.81	0.81	0.81	0.81
Phh	0.75	**0.60 – 0.88**	0.75	0.75	0.75

3. Numerical Results

The Hong and Rappaport mathematical traffic model is carried out in case 1 that to show the general effect of the probability of unblocked new call P_h on the handoff arrival calls λ_H. The typical values that performed in most of the wireless networks is about $P_h = 0.8$, but in this case it is evaluated as worst case than the normal one is clearly around $P_h = 0.7$ for in depth analysis. Case 2 is also greatly considered the impact of probability that a call that has already been handed off successfully would require another handoff, P_{hh}. The P_{hh} is deeply investigated under wider dynamic range than P_h. it is evaluated in between (*0.6 and 0.88*). Case 3 is quite different in network performance due to the fact that the probability of blocking originating calls *Bo* has a negative effect regardless of the analysis. *Bo* in the good wireless networks performance must always be in minimum range. In this case, it is in range of (*0.005 to 0.02*) because if it extended over high range of values that will definitely tend to bad network performance. The probability of handoff failure P_f is main issue that has catastrophic effect on all the network parameters, it is highlighted in between (*0.015 to 0.029*) and gives great effect in case 4. The key parameter that is playing an important role in the overall analysis is the arrival rate of originating calls in a cell λo that all the other parameters are related to it is main variation. As a result, it must have a great value to assist in evaluating the normal and critical situation in the network and it was taken from 0.68 up to 0.96. So, all cases provide different results regarding λ_H versus P_h, P_{hh}, *Bo*, P_f, *and* λo as listed in table 2 and related figures1, 2, 3, 4, 5. The effect of all different parameters that numerically calculated are all showed its important evaluation of their effects directly to the handoff arrival call rate λ_H in figures 1 to 5.

Table2 λH versus *Ph, Phh, Bo, Pf, and* λo.

Case 1		***Case 2***		***Case 3***		***Case 4***		***Case 5***	
Ph	λ_H	*Phh*	λ_H	*Bo*	λ_H	*Pf*	λ_H	λo	λ_H
0.70	**2.2751**	0.60	**1.6933**	0.005	**2.6459**	0.015	**2.6704**	0.68	**2.0577**
0.72	**2.3401**	0.62	**1.7779**	0.006	**2.6433**	0.016	**2.6628**	0.70	**2.1182**
0.74	**2.4051**	0.64	**1.8714`**	0.007	**2.6406**	0.017	**2.6552**	0.72	**2.1786**
0.76	**2.4701**	0.66	**1.9752**	0.008	**2.6380**	0.018	**2.6476**	0.74	**2.2393**
0.78	**2.5351**	0.68	**2.0913**	0.009	**2.6353**	0.019	**2.6401**	0.76	**2.2998**
0.80	**2.6002**	0.70	**2.2218**	0.01	**2.6327**	0.02	**2.6327**	0.78	**2.3601**
0.82	**2.6652**	0.72	**2.3697**	0.011	**2.6300**	0.021	**2.6252**	0.8	**2.4208**
0.84	**2.7302**	0.74	**2.5388**	0.012	**2.6273**	0.022	**2.6178**	0.82	**2.4814**
0.86	**2.7952**	0.76	**2.7338**	0.013	**2.6247**	0.023	**2.6105**	0.84	**2.5419**
0.88	**2.8602**	0.78	**2.9612**	0.014	**2.6220**	0.024	**2.6032**	0.86	**2.6024**
0.90	**2.9252**	0.80	**3.2299**	0.015	**2.6194**	0.025	**2.5959**	0.88	**2.6629**
0.92	**2.9902**	0.82	**3.5522**	0.016	**2.6167**	0.026	**2.5887**	0.9	**2.7234**
0.94	**3.0552**	0.84	**3.946**	0.017	**2.6140**	0.027	**2.5815**	0.92	**2.7840**
0.96	**3.1202**	0.86	**4.438**	0.018	**2.6114**	0.028	**2.5744**	0.94	**2.8445**
0.98	**3.1852**	0.88	**5.0702**	0.019	**2.6087**	0.029	**2.5673**	0.96	**2.9050**

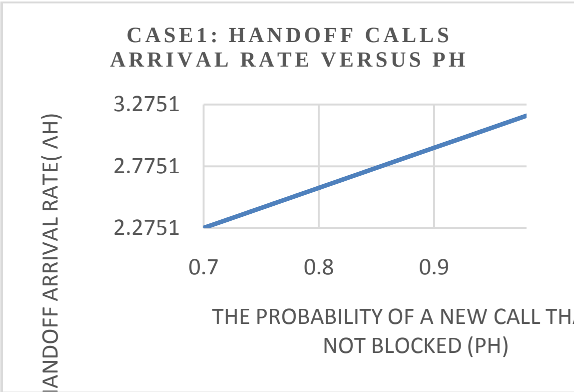

Figure1 Handoff calls arrival rate versus *Ph*

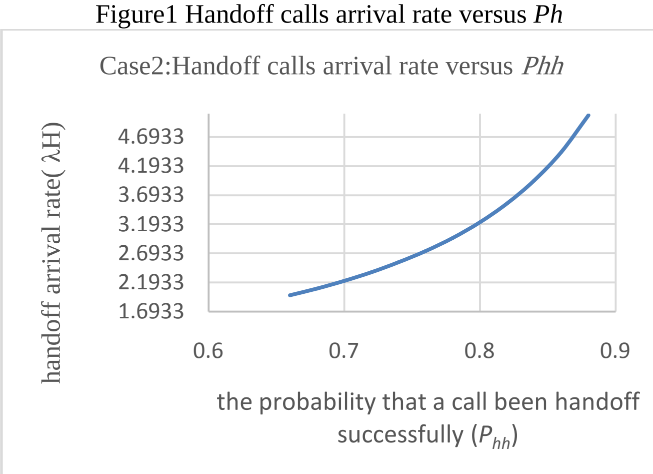

Figure2 handoff calls arrival rate versus *Phh*

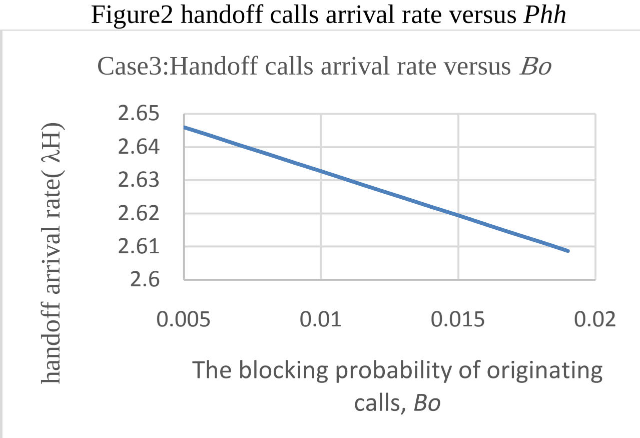

Figure3 handoff calls arrival rate versus *Bo*

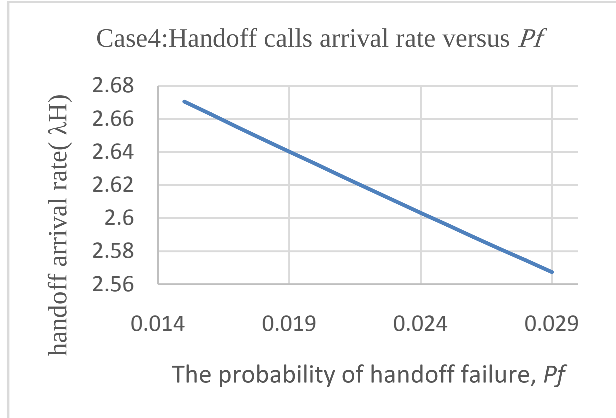

Figure4 handoff calls arrival rate versus *Pf*

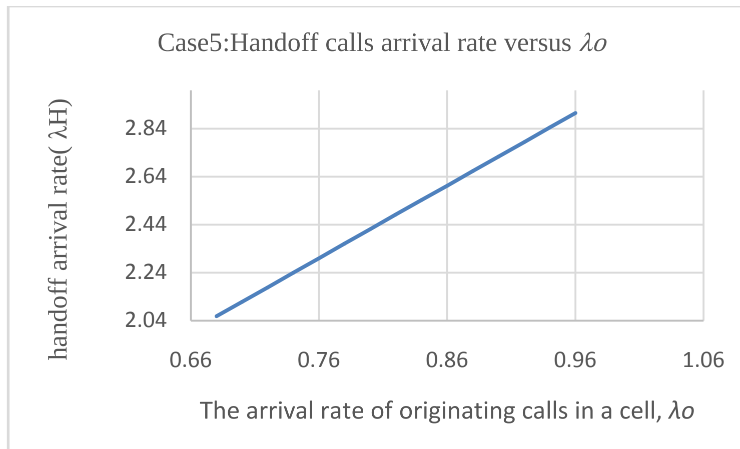

Figure5 handoff calls arrival rate versus λo

4. Discussion

In case 1, the probability of unblocked new call P_h has stronger effect on the handoff calls arrival rate λ_H more than the probability of a call that has already been handed off successfully would require another handoff P_{hh} particularly in between (0.7 – to - 0.8). whereas, the effect of P_{hh} is about twice in the range (0.8 - to - 0.9) as compared to the P_h as clearly shown in case 2. Both the probability of blocking originating calls *Bo* and the probability of handoff failure P_f are all tend to have the same effect on the handoff calls arrival rate λ_H. But in the range of (0.005 – to - 0.014), the effect of P_f is more than *Bo*. In other word, the *Bo* is a bit less than P_f as evaluated in figures 3 and 4. So, generally it can be concluded that, the handoff calls arrival rate:

- Is linearly proportional to both probability of unblock new calls (*Ph*) and the arrival rate of new calls (λo)
- It is also exponentially proportional to the probability that a call been handoff successfully (P_{hh})

- Is inversely proportional to the blocking probability of originating calls (*Bo)* and probability of handoff failure (*Pf*).

5. CONCLUSION

The system performance is evaluated under different cases and obtained good results. It is obviously shown that the probability that a call been handoff successfully (P_{hh}) has the strongest positives effect on the handoff calls rate (λ_H) compared to the other parameters. Whereas, the probability of handoff failure (*Pf*) has the strongest negative effect on (λ_H). This evaluation is clearly can be applied to the microcell where there is low cell capacity and most of the users are moving in the coverage area with different speeds.

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