International Journal of Emerging Engineering Research and Technology
Volume 6, Issue 5, 2018, PP 23-28
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

Performance Evaluation of Handoff Call Rate in Microcell of GSM Networks by Eldolil Traffic Model

Elsanosy M. Elamin[1], Yasir E. Nasir[2], Salwa A. Ibrahim[3], Rawya A. Malik[4]

Dept. of Electrical Engineering, Faculty of Engineering, University of Kordofan

***Corresponding Author:** Elsanosy M. Elamin, Dept. of Electrical Engineering, Faculty of Engineering, University of Kordofan.*

ABSTRACT

The principal aim of this work is to evaluate the network performance under various conditions to easily assist in improving the overall performance. The most important factor that contribute to the performance degradation is the handoff process which in turn resulted in call drop and block probabilities. Both probabilities are all impairing the quality of service (QoS). The evaluation is carried out at the microcell of wireless network which the users are moving in different speeds across the microcells. Mathematical El-Dolil et al.'s Traffic Model is performed and provided good numerical results about the effect of the probability that a user needs a handoff in the current microcell (Phi) , the average rate of total calls carried in neighboring microcell (Rcj), the rate of successful handoffs (Rsh), and the probability that a call that has already been handed off successfully would require another handoff (P_{hh}), on the handoff calls arrival rate (λ_H). These parameters are characterized into two different categories; constant and inconstant. The relevant four parameters were investigated and then calculated under multi different cases according to the system conditions which expressed in this paper as cases. Through the analytical process, the four different parameters show dissimilar degrees of impact on the handoff arrival call rate significantly(λ_H). Accordingly, it is found that the rate of successful handoffs (Rsh) has a positive effect on the handoff call arrival rate with different levels relaying on only the probability that a call that has already been handed off successfully would require another handoff (P_{hh}) in its minimum value, but in its maximum values it has a negative effect. Whereas, the average rate of total calls carried in neighboring cell has always a positive effect on arrival call rate significantly(λ_H) in all values of constant parameters values.

Keywords: *handoff arrival rate, call dropping, call blocking, handoff failure.*

INTRODUCTION

The fundamental issue that the network users are experienced as they utilized the network resources is the network congestion. As a result, many other various related problems are also corresponded such as call failure rate, call drop probability, call block probability, degradation of QoS. The most important difficulties that affect the overall network performance is the handoff process which normally took place several time and is greatly related to both holding time distribution and cell residence time. The handoff process is defined as transferring the ongoing call as the user travelling from one cell coverage area to another one with continuous services and the same QoS. It depends on changing the channel parameters such as frequency, time slot, spreading code, or combination of them, which relevant to the current connection and location while a call is in progress. The handoff process is often initiated either by departing a serving current cell boundary or by degradation in quality below a certain threshold value of the signal in the current channel of the current cell [5]. First generation doesn't focus on handoff which only uses one channel at any time, it has high probability to loss of connection and dropped call. The handoff process was mainly carried out by the network because the signal strength or levels were measured by base stations and supervised by Mobile Switching Centre (MSC) and lately the handoff decision was made by network which in turn is known as Network-Controlled Handoff. In addition to previous type, there are two different types of handoff decisions; Mobile-Assisted handoff and Mobile-Controlled Handoff [2, 3, 5]. Handoff process was significantly starting to affect the system performance since the second generation and up due to the growing of the low data rates and the gradual increasing of wireless network deployment [2]. In the second generation, there are a various types of handoff such as: Intra-BTS handoff, Inter-BTS Intra BSC handoff, Inter-BSC handoff, Inter-MSC handover. These various different handoff types characterized with a lot of features which enhanced the mobility and QoS at the cellular system [7, 8]. The signal levels were measured by base stations (BS) with feedback from mobile station (MS) and network made decision and controlled it, this results in less load on the network from handoff signaling. Handoff is a time-critical factor in wireless mobile network to provide seamless services under changing radio resource conditions [3]. Mobility and QoS all are the fundamental factors in wireless network to strongly support a continuous good service to improve the system performance [4]. On the other hand, its failure can result in ongoing call termination. The handoff failure probability is always associated with two crucial features; call dropping and call blocking probabilities. Both of them are so important in system performance improvement and capacity [2, 4]. A handoff failure is often due to lack radio resources such as bandwidth in the new cell because of low capacity and narrow cell coverage area, and consequently the call is dropped [8, 9]. The Call Dropping Probability (CDP) is a very important issue that associated with deterioration of QoS and is due to a handoff failure [4, 10].

THE MATHEMATICAL EL-DOLIL ET AL.'S TRAFFIC MODEL.

Mathematical and simulation models are two well-known techniques used to evaluate and improve or develop the system for better performance and balance. The principal task of the mathematical model is to obtain a more realistic numerical results that lead to reasonable conceptual frame work to improvement for better performance and capacity [11, 12]. There are some mathematical models were exploited to help in creating a deep logical and realistic notions about the system improvement or development. Accordingly, there are different mathematical traffic models used in analysis for evaluating and improving the system performance. So, there are some of them such as [5, 6]:

- Hong and Rappaport mathematical traffic model.
- Steele and Nofal traffic model.
- Eldolil traffic model.
- Xie and kuek's traffic model.
- Zeng et al.'s Approximated Traffic Model.

In this paper, the mathematical El-Dolil et al.'s traffic model is exploited to directly assist in in depth evaluation of the wireless communication network. The main parameter that can be directly evaluated according to the mathematical model is the handoff arrival call rate (λ_H) to continually assist in making some improvement in the system performance. This model is depending on different parameters that are all compose the entire nation about the key parameters with very high important positive effect on the overall performance. The model is clearly derived below in equation 1 as [6]:

$$\lambda_H = (R_{CJ} - R_{SH})P_{hi} + R_{SH}P_{hh} \qquad 1$$

Where, P_{hi} : the probability that a MS needs a handoff in current cell, R_{cj} : the average rate of total calls carried in neighboring cell, R_{sh} : the rate of successful handoffs, P_{hh} : the probability that a call that has already been handed off successfully would require another handoff [3, 6].

THE NUMERICAL RESULTS

In highway traffic the user can perform different calls during the travelling along the road till his destination, so that the wireless networks assist in performing the call that initiated by the user through the handoff process that carried out via microcellular radio network. Accordingly, there are six cases in this scenario to broaden the evaluation of the system performance [13, 14]. Therefore, the mathematical model parameters are considered as two categories; one as inconstant parameters and the other are as constant parameters as stated in table 1.

Table1. *The constant and inconstant and its related cases*

Constant Parameters			**R_{sh} is in the range (0.96 – 0.99) in all cases**					
Parameter	**Min**	**Max**	**Case 1**	**Case2**	**Case3**	**Case4**	**Case5**	**Case6**
P_{hh}	0.01	0.99	0.01	0.01	0.01	**0.99**	**0.99**	**0.99**
P_{hi}	0.1	0.2	0.1	**0.2**	**0.2**	0.1	**0.2**	**0.2**
R_{CJ}	0.95	0.99	0.95	0.95	**0.99**	0.95	0.95	**0.99**

The inconstant parameter that considered as main variable to help in evaluating the handoff call arrival rate is R_{sh}, it varied in wide range extended from (R_{sh} = 0.96 – to – 0.99) as a rate of successful handoff in all cases. In case 1 and 6, all values of constant parameters are in their minimum and maximum respectively.

Whereas, in cases 2 and 4 all the constant parameters are in their minimum except P_{hi} and P_{hh} in their maximum respectively. Cases 3 and 5, are all in their maximum values except P_{hh} *and* R_{CJ} respectively. Table 2 below shows the relevant numerical results.

Table2. *Handoff call arrival rate λH versus Rsh*

R_{sh}	λ_H(case1)	λ_H(case2)	λ_H(case3)	λ_H(case4)	λ_H(case5)	λ_H(case6)
0.9600	0.0086	0.0076	0.0156	0.9494	0.9484	0.9564
0.9621	0.0084	0.0072	0.0152	0.9513	0.9501	0.9581
0.9643	0.0082	0.0068	0.0148	0.9532	0.9518	0.9598
0.9664	0.0080	0.0064	0.0144	0.9551	0.9535	0.9615
0.9686	0.0078	0.0060	0.0140	0.9570	0.9552	0.9632
0.9707	0.0076	0.0056	0.0136	0.9589	0.9569	0.9649
0.9729	0.0074	0.0052	0.0132	0.9608	0.9586	0.9666
0.9750	0.0072	0.0047	0.0128	0.9627	0.9602	0.9682
0.9771	0.0071	0.0043	0.0123	0.9647	0.9619	0.9699
0.9793	0.0069	0.0039	0.0119	0.9666	0.9636	0.9716
0.9814	0.0067	0.0035	0.0115	0.9685	0.9653	0.9733
0.9836	0.0065	0.0031	0.0111	0.9704	0.9670	0.9750
0.9857	0.0063	0.0027	0.0107	0.9723	0.9687	0.9767
0.9879	0.0061	0.0023	0.0103	0.9742	0.9704	0.9784
0.9900	0.0059	0.0019	0.0099	0.9761	0.9721	0.9801

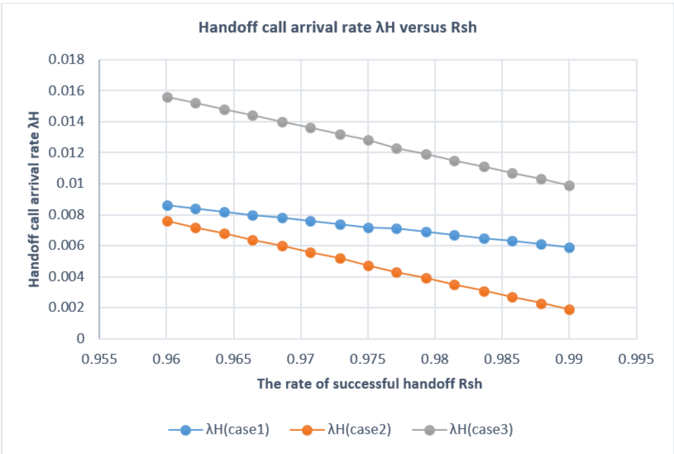

Fig1. *handoff calls arrival rate versus Rsh (cases1,2,3)*

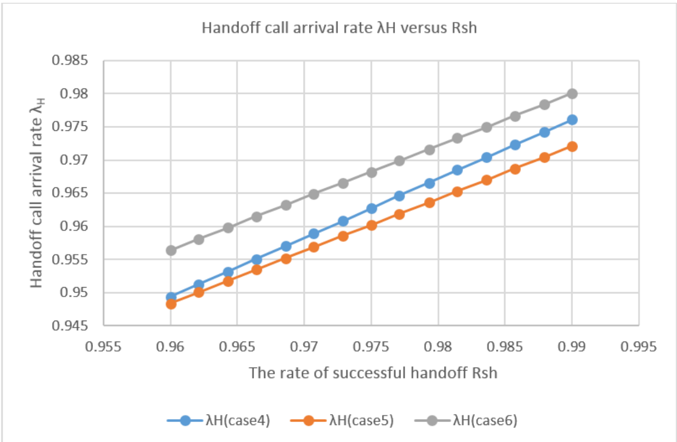

Fig2. *handoff calls arrival rate versus Rsh (cases4,5,6)*

Now, the inconstant parameter also considered as main variable to help in evaluating the handoff call arrival rate is R_{CJ} it varied in wide range extended from (R_{CJ} = 0.95 – to – 0.99) as the average rate of total calls carried in neighboring cell in all cases.

In addition, R_{sh} is swapped with the R_{CJ} as shown in table 3.

Table3. *the constant and inconstant and its related cases*

Constant Parameters			R_{CJ} is in the range (0.95 – 0.99) in all cases					
Parameter	**Min**	**Max**	**Case 1**	**Case2**	**Case3**	**Case4**	**Case5**	**Case6**
P_{hh}	0.01	0.99	0.01	0.01	0.01	**0.99**	**0.99**	**0.99**
P_{hi}	0.1	0.2	0.1	**0.2**	**0.2**	0.1	**0.2**	**0.2**
R_{sh}	0.96	0.99	0.96	0.96	**0.99**	0.96	0.96	**0.99**

Table 2 below shows the relevant numerical results of handoff call arrival rate λ_H versus the average rate of total calls carried in neighboring cell R_{CJ}.

Table4. *handoff call rate λ_H versus R_{CJ}*

R_{cj}	λ_H(case1)	λ_H (case2)	λ_H (case3)	λ_H (case4)	λ_H (case5)	λ_H (case6)
0.9500	0.0086	0.0076	0.0019	0.9494	0.9484	0.9721
0.9529	0.0089	0.0082	0.0025	0.9497	0.9490	0.9727
0.9557	0.0092	0.0087	0.0030	0.9500	0.9495	0.9732
0.9586	0.0095	0.0093	0.0036	0.9503	0.9501	0.9738
0.9614	0.0097	0.0099	0.0042	0.9505	0.9507	0.9744
0.9643	0.0100	0.0105	0.0048	0.9508	0.9513	0.9750
0.9671	0.0103	0.0110	0.0053	0.9511	0.9518	0.9755
0.9700	0.0106	0.0116	0.0059	0.9514	0.9524	0.9761
0.9729	0.0109	0.0122	0.0065	0.9517	0.9530	0.9767
0.9757	0.0112	0.0127	0.0070	0.9520	0.9535	0.9772
0.9786	0.0115	0.0133	0.0076	0.9523	0.9541	0.9778
0.9814	0.0117	0.0139	0.0082	0.9525	0.9547	0.9784
0.9843	0.0120	0.0145	0.0088	0.9528	0.9553	0.9790
0.9871	0.0123	0.0150	0.0093	0.9531	0.9558	0.9795
0.9900	0.0126	0.0156	0.0099	0.9534	0.9564	0.9801

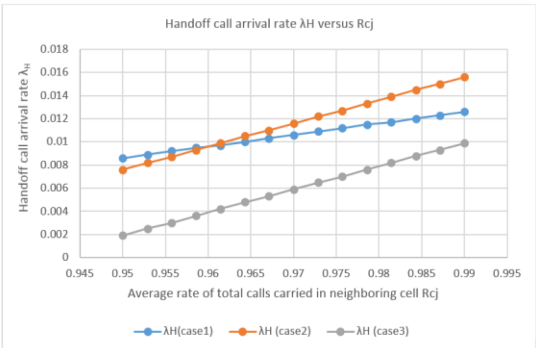

Fig3. *handoff calls arrival rate versus Rcj(cases1.2.3)*

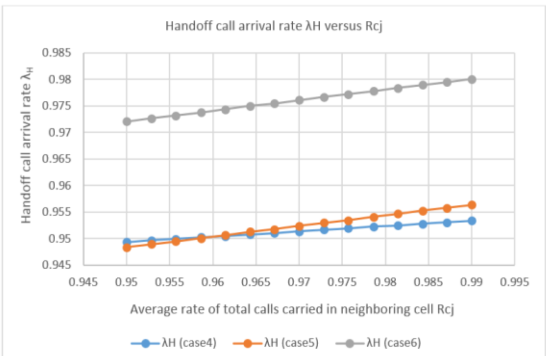

Fig4. *handoff calls arrival rate versus Rcj(cases4.5.6)*

Discussion

The handoff process is performed as a result of its arrival rate at the microcells radio network. So, the obtained numerical results about the effect of the rate of successful handoffs (R_{sh}) on handoff call arrival rate (λ_H) is listed in table 2 and relevant fig 1 and 2. In fig 1, it is found that the rate of successful handoffs R_{sh} is inversely proportional to the handoff call arrival rate λ_H. Fig 1 clearly shows that the effect of the rate of successful handoffs R_{sh} in case 2 is minimal, whereas case 3 is the most effective one. And both case 2 and 3 are follow the same behavior with great variation in λ_H from 0.0076 as start value in case 2 as compared to 0.0156 also as start value in case 3 depending on the little variation in the R_{CJ} from 0.95 – to – 0.99. case 1 has different behavior and its effect is limited in small range of λ_H from 0.0086 to 0.0059 due to low values of the constant parameters (P_{hh}, P_{hi}, and R_{CJ}). Cases 5 and 6 their effects are similar but are begin with great different values (0.9484 for case 5 and for case 6). Case 4 is quite different from both case 5 and 6 due to only maximum value of the probability that a call that has already been handed off successfully would require another handoff P_{hh}. Generally, it is found that handoff call arrival rate λ_H is directly proportional to the rate of successful handoffs R_{sh} in cases 1, 2, 3 regardless of the minimum and maximum values of the constant parameters (P_{hh}, P_{hi}, and R_{CJ}). Table 3 with the related figure 3 and 4 are all express the numerical results that associated with the average rate of total calls carried in neighboring cell (R_{cj}) as a variable parameter versus the handoff call arrival rate λ_H. In figure 3, it no doubt that both case 2 and 3 are all perform the same behavior relying on the rate of successful handoffs (R_{sh}) from 0.96 – to – 0.99. Whereas, case 1 is changed in quite different manner but case 1 is intersect with the case 2 at value of R_{cj} = 0.9643. in figure 4, it is remarkable that case 3 with values greater than in case 1 figure 3.

Conclusion

The mathematical Eldolil model is analytically used with various cases depending on the minimum and maximum values of constant parameters, it provided reasonable and realistic evaluation that may help in creating a conceptual framework to improve or develop the system performance and directly enhance the overall capacity of the system. The results also show that the rate of successful handoffs (R_{sh}) is directly proportional to the handoff call arrival rate (λ_H) with different levels relaying on only P_{hh} in its minimum value. Whereas, the rate of successful handoffs (R_{sh}) is inversely proportional to the handoff call arrival rate (λ_H) with various different levels depending on only P_{hh} in its maximum value. The relationship between the handoff call arrival rate (λ_H) and (Rcj) show that the (Rcj) is always directly proportional to the (λ_H) with various degrees regardless of the constant parameters (P_{hh}, P_{hi}, and R_{sh}). The values of cases 1, 2, 3 are all inverted with the values in cases 4, 5, 6 as a result of P_{hh} as it changed from minimum (P_{hh} =0.1) to the maximum value (P_{hh} =0.99).

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Citation: *Elsanosy M., E., Yasir E., N., Salwa A., I. and Rawya A., M. (2018). "Performance Evaluation of Handoff Call Rate in Microcell of GSM Networks by Eldolil Traffic Model". International Journal of Emerging Engineering Research and Technology, 6(5), pp.23-28.*