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A COMPARATIVE STUDY OF PRIORITIZED HANDOFF SCHEMES WITH GUARD CHANNELS IN WIRELESS CELLULAR NETWORKS

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ABSTRACT
Mobility management has always been the main challenge in most mobile systems. It involves the management of network radio channel resource capacity for the purpose of achieving optimum quality of service (QoS) standard. In this era of wireless Personal Communication Networks such as Global System for Mobile Communication (GSM), Wireless Asynchronous Transfer Mode (WATM), Universal Mobile Telecommunication System (UMTS), there is a continuous increase in demand for network capacity. In order to accommodate the increased demand for network capacity (radio resource) over the wireless medium, cell sizes are reduced. As a result of such reduction in cell sizes, handoffs occur more frequently, and thereby result in increased volume of handoff related signaling. Therefore, a handoff scheme that can handle the increased signaling load while sustaining the standard QoS parameters is required.This work presents a comparative analysis of four popular developed handoff schemes. New call blocking probability, forced termination probability and throughput are the QoS parameters employed in comparing the four schemes. The four schemes are:RCS-GC,MRCS-GC, NCBS-GC, and APS-GC. NCBS-GChas the leased new call blocking probability while APS-GC has the worst. In terms of forced termination probability, MRCS-GC has the best result, whileRCS-GChas the worst scheme.MRCS-GC delivers the highest number of packets per second while APS-GC delivers the least. These performance metrics are computed by using the analytical expressions developed for these metrics in the considered models in a Microsoft Excel spreadsheet environment.

Keywords: *Blocking probability, wireless network, handoff, guard channel*

1. INTRODUCTION

The rapid growth of mobile users and mobile devices, and consequently, the high demand for wireless resources affect the quality of service of personal communication Networks (PCNs). Therefore, it is necessary to develop a resource sharing scheme in order to achieve optimum resource utilization [1, 2]. Frequency reuse and channel assignment techniques were proposed for the existing PCNs.These PCNs includes Global system for mobile communication (GSM) system, Wireless Asynchronous Transfer Mode (WATM) systems, Universal Mobile Telecommunication Systems (UMTS), etc. The techniques ensure that a call originated by a user terminal in a cell is completed by the base station assigned to that cell area. But, when the radio resources in the base station area are completely utilized, the call is forwarded to an adjacent base station area with idle resources. In this case, a new channel frequency is required to sustain the call. This process of sustaining a call when a mobile terminal moves from one cell to another is known as handoff [3, 4]. Multiple handoffs could occur in a single ongoing call. The channel is released by the terminal when a call is completed either in the source cell where the call is originated or in the handoff cell. The handoff cell is also referred to as the target cell in literature [5]. Handoff occurs frequently in a cluster with small cell radii and it has a direct impact on the quality of service (QoS)experienced by the users [5].The presence of small cell radii such as the Microcell and thePico-cells in a cluster may result in frequent call dropping (forced termination) of users'calls,which cross the boundary of the base station area [3]. Frequent call termination in a wireless system is very worrisome and it leads to poor QoS to the wireless network. Different approaches were proposed to reduce the handoff dropping probability [3]. One approach used in reducing the handoff dropping is the

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application of resource allocation schemes.This gives precedence to handoff calls. Such schemes permit high utilization of bandwidth as well as guarantee optimal quality of service for handoff calls [6]. Some prioritized handoff access methods are the guard channels (GC), the call admission control (CAC) and the handoff queueing priority schemes (QPS). Better still, hybrid of these schemes with channel allocation algorithms yield good performances [6,7,8]. The GC is referred to as the cutoff priority scheme. Cutoff priority scheme (CPS) is fundamental in a handoff process. The CPS enhances handoff performance in a PCN simply by reserving a number of channels for the handoff process. When all channels are occupied, either new calls are queued while handoff calls are blocked or new calls are blocked while handoff calls are queued [9, 10]. In this paper, we discuss and compare fourhandoff algorithms used in a PCN network. A typical cellular system used in illustrating the handoff process is shown in Figure 1[3]. The architecture shown in Figure 1 is a typical structure of a wireless PCN network. It comprises the user terminals, the base station (the cell site), the cells, the mobile switching centers (MSCs) and the public switched telephone network (PSTN). The base stations in each of the cells are linked with the mobile switching centers as shown in Figure 1. In addition, the MSCs are linked with the PSTN. This is because the majority of the calls in a cellular mobile system either originate from or terminate at fixed network terminals. The coverage area of the cellular system is partitioned into a number of smaller areas or cells with each cell being served by a base station (BS). The base stations are connected through fixed links to a mobile switching center (MSC), which is a local switching exchange with additional features to handle mobility management requirements of a cellular system. To accommodate the mobility of terminals and the subscription of data, the MSC interacts with some form of database that maintains the subscriber data, and the location information.

Based on the frequency spectrum made available by the licensing authority and the cellular standards, the cellular system is able to define a number of radio channels used across its serving area. These radio channels are partitioned into groups of channels, which are allocated to individual cells forming the entire service area. Individual channels or a particular group of channels can be reused in the cells that are located some distance away. Key features of PCN radio, consist of designing the cell sizes, and allocating radio channels to individual cells. In each cell, one radio channel is set aside for carrying signaling information between the network (i.e., the base station) and the mobile stations in that cell. Signaling is used in the mobile-to-BS direction to carry signals for location updating, mobile-originated call setup, and responses to the incoming call,the setup messages (e.g., paging response), etc. In the reverse direction (BS-to-mobile) the signaling channel carries messages related to operating parameters (e.g., location area identification, cell identity), call setup (e.g., paging), and location updating

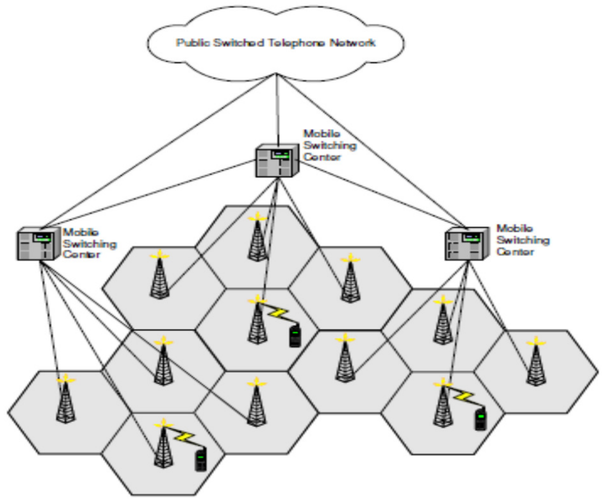

Fig. 1: A cellular system with hexagonal cells

2. REVIEW OF RELATED LITERATURE

Many researchers have proposed various types of handoff schemes. The schemes can broadly be classified into non-priority and priority schemes.When no priority is accorded to new or handoff calls, the probabilities of blocking a new call and handoff probability are equal.This is referred to as non-priority scheme (NPS). In other words,the NPS does not differentiate new calls from handoff calls [3]. If a request is made and a channel is available, one channel is assigned to this request. If there are no free channels, the request is rejected immediately and the call is cleared from the PCN [4].However, forced termination is less desirable when compared to call blocking,from the user's viewpoint [12]. Blocking and forced termination probability is represented by M/M/C/C model proposed by Erlang[13]. This implies that the arrival process is poisson (memoryless), the service times are exponentially distributed, there are C service facilities and the last C denotes a hard limit on the number of simulthanous users that are served. Analytical expressions were developed in [13] for this model. Observation of the expression shows that it represents a loss system, and it deals with the service facility (channels) only. The blocking probability of the fresh or handoff calls is simply the probability of the number users accommodated in the system[12].

At times, a FIFO queue is attached to the non-prioritized scheme. The system becomes a lossless system. In loseless systems, the arrival rate is the sum of the fresh and handoff call rates. However, when the number of requests in the system is equal to or more than the number of service facility (channels), only the handoff calls are queued. The blocking probability of the system becomes the sum of the blocking probability of fresh and handoff calls [13].

Priority Schemes (PSs) give high preference to handoff calls and a low preference to new calls. The PS is very suitable for the PCN networks. Therefore, it is the focus of this paper. To reduce forced termination many generic prioritization schemes have been proposed. The Reserved channel scheme (RCS) is a popular PS scheme. It reserves a fraction of channels in a base station for handoff calls only while the remaining channels are allocated to both new and handoff calls. Sometimes a queueing facility is attached to the RCS scheme to queue the handoff calls when all the servers (channels) are fully occupied [14]. Reservation of channels for handoff simply implies allocating fewer channels to fresh calls in favour of handoff calls. Channels reservation is also referred to as guard channels (GC).The GC serves as a means of improving the probability of successful handoff. The use of the GC requires a careful determination of the optimum number of channels, a knowledge of the traffic pattern, and a proper estimation of the channel occupancy distribution. The GC can be fixed or dynamic. In cases where there are several handoff requests in the queue, they can be served either by the use First-In-First-Out (FIFO) or by a Measured-Based Priority scheme (MBPS). The order of service in this case is determined by the power level that the mobile station receives from the new base station. The mobile station with the lowest signal level or the poorest quality of service is served first [15]. The main disadvantage of the RCS is the decreasing of the offered load to the cell [16]. A multiple-threshold bandwidth reservation scheme combined with a call admission control algorithm was developed by [21]. This scheme is an enhanced guard channel scheme called the Multimedia Guard Channel (MGC). It is modelled as M/M/C/C queuing system and three quality of services (QoS) metrics are computed and compared with the Complete Sharing (CS) scheme where all the classes of traffic have equal probability of accessing the service facilities. The QoS parameters considered are call blocking probability (CBP) for new calls, call dropping probability (CDP) for handoff calls and the bandwidth utilization of the classes of traffic under study. A series of bandwidth threshold determines the maximum amount of bandwidth that connections in each category of call can use. The scheme proved to be better than the Complete Sharing scheme. In most literatures for prioritized handoff schemes, a single queue for handoff call is always considered for the whole cell in a microcellular networks. However, [22] modified [13] to propose a new model for optimization of handoff procedure. In this model, there is a separate queue for each transceiver (TRX) of the same cell in line with the recommendation of Nokia for operators that use multilayer cellular architectures in their networks. [23] proposed a new handoff scheme which eliminates pseudo (false) handoff calls to improve channel utilization efficiency based on mobility information. This soft handoff scheme which is an application of loss formulas was developed for CDMA cellular systems. Evaluation and comparison of the conventional schemes and this scheme showed effectiveness of this scheme in terms of new call blocking probability and handoff dropping probability. Also, in most of the previously proposed schemes for radio channel allocation in wirless network, the design goal was to reduce the handoff dropping probability at the expense of new call blocking probability. This concept reduces the total admitted traffic and results in inefficient utilization of wireless channels. [24] however, proposed a dynamically adaptive channel reservation scheme (DACRS). The DACRS assigns handoff-reserved channel to new calls depending on the locality principle in which the base station with help of location estimation algorithms in the mobile location centre predicts the position of the mobile terminal. The authors proved that this scheme performed better than the GCS and dynamic channel reservation scheme (DCRS).

3. PRIORITIZED HANDOFF MODEL

The Reserved Channel Scheme with guard channels was presented in the paper (RCS-GC) [13]. In this scheme, the authors gave priority to handoff attempts by assigning C_h channels exclusively to handoff calls among the C channels in a cell. The remaining $C-C_h$ channels are shared by both the new calls and handoff calls. A new call is blocked if the number of available channels in the cell is less than or equal to C_h as at the time the new call is originated. The mean arrival rate rates per cell of newcall and the handoff attempt rates are generated from the Poisson point process with rates λ_R and λ_{Rh}, respectively. The handoff service rate is μ_H. The steady state transition probability of the RCS-GC is illustrated in equation (1) [13].

$$P_j = \begin{cases} \dfrac{(\lambda_R+\lambda_{Rh})^j}{j!\mu^j{}_H} P_0 & for\, j=1,2,\ldots,C-C_h \\ \dfrac{(\lambda_R+\lambda_{Rh})^{C-C_h}\lambda_{Rh}^{j-(C-C_h)}}{j!\mu_H^j} P_0 & for\, j=C-C_h+1,\ldots,C \end{cases} \quad (1)$$

Where,

$$P_0 = \left[\sum_{k=0}^{C-C_h} \frac{(\lambda_R+\lambda_{Rh})^k}{k!\mu_H} + \sum_{k=C-C_h+1}^{C} \frac{(\lambda_R+\lambda_{Rh})^{C-C_h}\lambda_{Rh}^{k-(C-C_h)}}{k!\mu_H{}^k}\right]^{-1}$$

Also, the blocking probability of new calls and handoff calls are illustrated in equation (2)-(3) [10].

$$Pb_N = \sum_{C-C_h}^{C} P_j \quad (2)$$

$$P_{fh} = P_C \quad (3)$$

A modified non-uniform compact pattern allocation algorithm is presented in [8]. The non-uniform pattern allocation algorithm is a channel allocation scheme which is based on a traffic distribution. This algorithm takes into account the new call arrival rate and the handoff arrival rates in a given cell. One of its important features is the borrowing of channels from adjacent cells when the channels in a particular cell are fully occupied. Consequently, the algorithm which is amodified non-uniform algorithm is applied to a dynamic channel allocation (DCA) strategy. The modified algorithm is called the compact pattern with maximized channel borrowing (CPMCB). It minimizes both the blocking rate of new calls and handoff failure. The CPMCB algorithm is combined with the modified Reserved Channel Scheme (MRCS) to determine the blocking probability of new call and the handoff blocking probability. Also, the MRCS employs the guard channel technique of queuing theory. It is therefore known as the MRCS with guard channel (MRCS-GC) scheme. The transition probability of the MRCS is shown in equation (3)- (4) [8].

$$P_j = \begin{cases} \dfrac{\left(\dfrac{\lambda_n+\lambda_h}{\mu+\eta}\right)^j}{j!} P_0 & 0 < j < n \\ \dfrac{(\lambda_h)^{j-n}(\lambda_n+\lambda_h)^n}{(\mu+\eta)^j\, j!} P_0 & n < j \le s \end{cases} \quad (4)$$

Where, $P_0 = \sum_{j=0}^{n} \frac{\left(\frac{\lambda_n+\lambda_h}{\mu+\eta}\right)^j}{j!} P_0 + \sum_{j=n+1}^{s} \frac{(\lambda_h)^{j-n}(\lambda_n+\lambda_h)^n}{(\mu+\eta)^j\, j!} P_0$

Thus, the expressions of the new call blocking probability and the handoff blocking probability of the MRCS scheme are [8]:

$$Pb_N = \sum_{j=n}^{S} P_j \quad (5)$$

$$Pb_h = P_s \quad (6)$$

New Call Bounding Scheme (NCBS) directly controls new calls admitted into a network during congestion. It is a Call Admission Control (CAC) scheme which provides a desired QoS to newly admitted calls. As a CAC scheme, it guarantees satisfactory QoS for ongoing calls [9]. The NCBS is analysed with two dimensional Markov chain. In principle, if the number of new calls in a cell exceeds a threshold, arriving new calls are rejected. But, the handoff calls are only blocked when all the channels are occupied. Another word for threshold is cutoff or guard channel. Thus, this paper renamed the NCBS as NCBS with guard channel (NCBS-GC). The NCBS-GC accepts few new calls instead of dropping ongoing calls [10]. So the NCBS-GC is also a guard channel scheme and a priority scheme as well. The transition equations of NCBS-GCis given in expressions (7)-(10)[17] and the new call and handoff call blocking probabilities are illustrated in equations (11) - (12), respectively.

$$q(n_1,n_2;n_1-1,n_2) = n_1\mu_n(0 < K, 0 \le n_2 \le C) \quad (7)$$

$$q(n_1,n_2;n_1+1,n_2) = \lambda_n(0 \le n_1 \le K, 0 \le n_2 \le C) \quad (8)$$

$$q(n_1,n_2;n_1,n_2-1) = n_2\mu_n(0 \le n_1 \le K, 0 \le n_2 \le C) \quad (9)$$

$$q(n_1,n_2;n_1,n_2+1) = \lambda_n(0 \le n_1 \le K, 0 \le n_2 \le C) \quad (10)$$

$$Pb_N = \frac{\sum_{n_2=0}^{C-K} \frac{\rho_n^K}{K!}\frac{\rho_h^K}{n_2!} + \sum_{n_1=0}^{K-1} \frac{\rho_n^{n_1}}{n_1!}\frac{\rho_h^{C-n_1}}{(C-n_1)!}}{\sum_{n_1=0}^{K} \frac{\rho_n^{n_1}}{n_1!} \sum_{n_2=0}^{C-n_1} \frac{\rho_h^{n_2}}{n_2!}} \quad (11)$$

$$Pb_h = \frac{\sum_{n_1=0}^{K-1} \frac{\rho_n^{n_1}}{n_1!}\frac{\rho_h^{C-n_1}}{(C-n_1)!}}{\sum_{n_1=0}^{K} \frac{\rho_n^{n_1}}{n_1!} \sum_{n_2=0}^{C-n_1} \frac{\rho_h^{n_2}}{n_2!}} \quad (12)$$

In the NCBS-GC scheme, the admission of new calls was based on a guard channel. However, when new calls are accepted based on the entirety of the ongoing calls in an access point, an approximate one dimensional Markov process replaces the two dimensional Markov process in the NCBS scheme. The approximate one dimensional Markov technique is referred to as the Approximate priority scheme with guard channel (APS-GC). This scheme was studied in [17] and the expression for the blocking probability and the handoff probability are illustrated in equations (13)-(14).

$$Pb_N^a = \frac{\sum_{j=m}^{C} \frac{(\rho+\rho_h)^m \rho_h^{j-m}}{j!}}{\sum_{j=0}^{m} \frac{(\rho+\rho_h)^j}{j!} + \sum_{j=m+1}^{C} \frac{(\rho+\rho_h)^m \rho_h^{j-m}}{j!}} \quad (13)$$

$$Pb_h^a = \frac{\frac{(\rho+\rho_h)^m \rho_h^{C-m}}{j!}}{\sum_{j=0}^{m} \frac{(\rho+\rho_h)^j}{j!} + \sum_{j=m+1}^{C} \frac{(\rho+\rho_h)^m \rho_h^{j-m}}{j!}} \quad (14)$$

4. COMPARATIVE ANALYSIS OF THE SIMULATION RESULTS

The analytical expressions derived for new call blocking probabilities and handoff forced termination probabilities for the various schemes are used in computing these QoS parameters using Microsoft Excel spreadsheet. The parameters used for the computation of the quality of service metrics are: new call arrival rate (λ) = handoff arrival rate (λh) = 0.6 packets/sec., the channel holding rate for new call = channel holding rate for handoff call (μ). The value of μ is varied from 0.1 to 0.9 packets/sec.

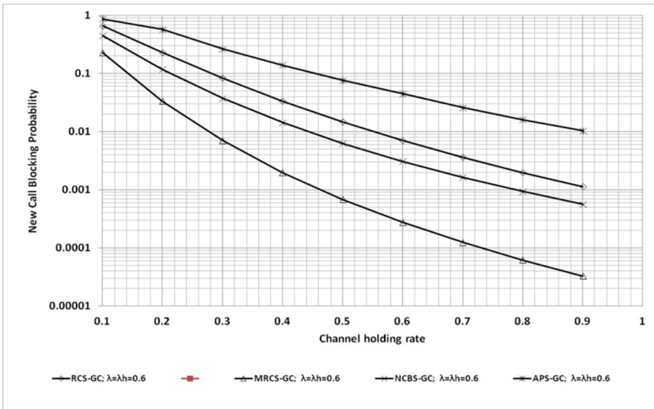

Fig. 2: New call blocking probability vs. Channel holding rate

Figure 1 illustrates the relationship between the blocking probability of new calls and channel holding rate for the five handoff schemes. It was observed that the new call blocking probability decreases with the increase in channel holding rate. The most effective scheme is the MRCS-GC scheme as it is the scheme with the least blocking probability of new calls. The blocking scheme reduces from 0.043 to 2.4e10^{-9} when the channel rate increases from 0.1 to 0.9 respectively. The worst scheme is the APS-GC scheme with cutoff threshold. It's blocking probability decreases from 0.0875 to 0.01 with the increase in channel rate from 0.1 to 0.9 respectively.

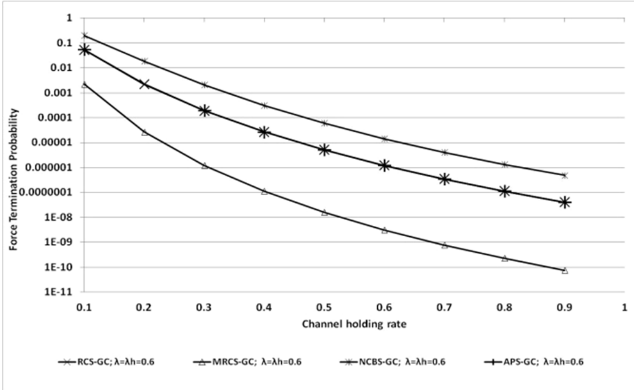

Fig. 3: Forced termination probability vs. channel holding rate

Figure 3 shows the curves of forced termination probabilities against the channel holding rate. It reveals that the forced termination probability decreases with increase in the channel holding rate in all the schemes. However, MCRS-GC scheme has the best force termination probability because it presents smallest value for terminating ongoing calls. It presents a termination value 0.0022 at a channel rate 0.1packets/second and a value 7.7x10^{-11} when the channel rate is 0.9 packets/second. The worst scheme is the NCBS-GC scheme. NCBS-GChandoff probability decreases from 0.2 when the channel rate is 0.1 packets/second, to 4.9x10^{-7} when the channel rate is 0.9.

The throughputs of the individual schemes are computed from the expression in equation (15) [13,18].

$$S = \lambda(1 - Pb) \quad (15)$$

The characteristics of the throughput against the new call blocking probabilities are depicted in Figure (3). The ranges of values of the probabilities are different. The throughput of the four schemes can be compared by generating the throughput expression as a function of the new call blocking probability, by applying the least-square method and the square of the correlation of the measure of reliability. The throughput is predicted from the observed data in Figure 2 by the applying exponential curve fitting (ECF) model and the least-square technique in equations (16)–(17) [19, 20]. The general form of the ECF model is shown in equation (16), and it is used to generate the trend lines in Figures 4. Specifically, the equation of the regression through the origin (RTO) and ordinary least-square (OLS) techniques are employed. The final result after manipulation constitutes what is usually known as the analysis of variance (ANOVA). The Square of correlation determines the relationship between the throughput and the blocking probability, whereas the OLS equation estimates or predicts the characteristics of the throughput given the new call blocking probability. Equations(16)-(17) is computed from the trend line option in Microsoft Excel spreadsheet. Equations (18)-(22) represent the ECF models of the throughputs as a function of the new call blocking probabilities as well as the square of correlations. These are computed with the trend line function of the spreadsheet.

$$R^2 = 1 - \frac{\sum\left(Y_i - \hat{Y}_i\right)^2}{\sum\left(Y_i - \bar{Y}\right)^2} \quad (16)$$

and

$$Y = ce^{bx} \quad (17)$$

In (16) and (17), Y is the throughput, X is the new call blocking probability, c and b are constants, e is the base of the natural logarithm, $\bar{Y}$ is the mean of throughput, $\hat{Y}_i$ is the ith fitted value of throughput and Y_i is the actual ith value of throughput.

$$Y = 102.08e^{-1.626x}$$
$$R = 0.9884 \quad (18)$$

$$Y = 100e^{-1.022x}$$
$$R = 1 \quad (19)$$

$$Y = 100.06e^{-1.137x}$$
$$R = 0.9998 \quad (20)$$

$$Y = 100.55e^{-1.326x}$$
$$R = 0.9972 \quad (21)$$

$$Y = 110.26e^{-2.195x}$$
$$R = 0.9426 \quad (22)$$

The throughput drops as the new call blocking probability increases from 0.1 to 0.9. From Figure 3, the curves diverge as the service rate is increased. The al delivers the highest number of packets per second. It is thus the best scheme. The number of packets increases from 40-90 packets/second as new call blocking probability decreases from 0.9 - 0.1 The worst scheme in terms of packet delivery per second is the APS-GC scheme. It has a throughput value of about 89 packets when the new call blocking probability is 0.1 and a throughput of only 15 packets/second when the new call blocking probability is 0.9.

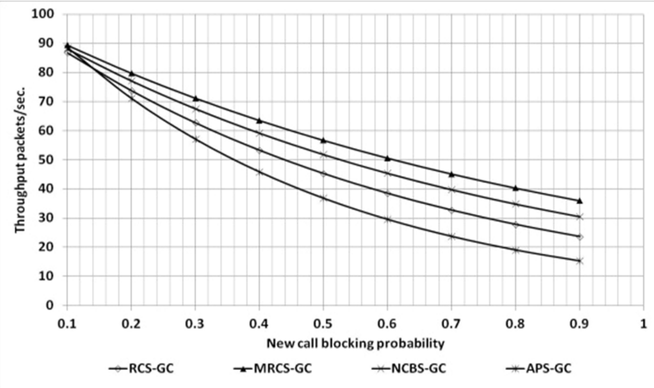

Fig. 4: Throughput against the new call blocking probability

5. CONCLUSIONS

This paper studies the quality of service comparison of four handoff schemes. The metrics employed in the comparison are new call blocking probability, handoff forced termination probability and the throughput.

MRCS-GC has the leased new call blocking probability while APS-GC has the worst. In terms of forced termination probability, MRCS-GC has the best result, whileRCS-GChas the worst scheme. MRCS-GC al delivers the highest number of packets per second while APS-GC delivers the least. In summary MRCS-GC appears to be the best as it has the least new call blocking probability and delivers the highest packets per second.

6. REFERENCES

1. Lee D.C, Park S. K and Song J. S, “Performance Analysis of queueing Strategies for Multitple Priority Calls in Multiservice Personal Communications Services,” *Elsevier Computer Communications* vol. 23, 2000, 1069-1083.
2. Swain P. K and Goswami V, “Analytical Modeling for Handling Poor Signal Quality Calls in Cellular Network,” *International Journal of Networks and Communications* 2012, vol. 2, no. 4, pp. 47-54.
3. Lai W. K, et al, “Channel Assignment for Initial and Handoff Calls to Improve the Call-Completion Probability”, IEEE Transaction on Vehicular Technology, Vol.52,No. 4, July 2003.
4. Fantacci Romano, “Performance Evaluation of Prioritized Handoff Schemes in Mobile Cellular Networks”, IEEE Transactions on Vehicular Technology, Vol. 49, No 2, March 2000.
5. Ariton E. Xhafa et al, “Dynamic Priority Queueing of Handover Calls in Wireless Networks: An Analytical Framework”, IEEE Journal on Selected Areas in Communications, vol. 22, no. 5, June, 2004.
6. Khan J., “Handoff Management in GSM cellular System,” *International Journal of Computer Applications*, vol. 8, no.12, Oct. 2010, pp. 14-24.

7. Hou J and Fang Y, "Mobility-Based Call Admission Control Schemes for Wireless Mobile Networks," *Wireless Commun. Mob. Comput.*, vol. 1, 2001, pp. 269-282.

8. Ortigoza-Guerrero L and Aghvami A. H, "A Prioritized Handoff Dynamic Channel Allocation Strategy for PCS", IEEE Transactions on Vehicular Technology Vol. 48, No. 4, July 1999.

9. Lee C. Y, "Wireless and Cellular Telecommunications," 3rded., McGraw-Hill, New York, 2006, 485-507.

10. Rappaport T. S, "Wireless Communications: Principles and Practice," 2nd ed., Prentice Hall, 2002, pp1-641.

11. Bhoite K and Vidyapeeth B, "Call Admission Control Policy for handoff call congestion control", *International Journal of Advanced Research in Computer Science and Electronics Engineering*, vol. 2, no 5, May 2013.

12. Tekinay S and Jabbari B, "A Measurement-Based Prioritization Scheme for Handovers in Mobile Cellular Networks," IEEE Journal in Sel. Areas in Communications, vol 10, no. 8, Oct. 1992, pp. 1343-1350.

13. Hong D and Rappaport S. S, "Traffic Model and Performance Analysis for Celleular Mobile Radio Telephone Systems with Prioritized and Nonprioritized Handoff Procedures-Version 2b," Department of Electrical and Computer Engineering, University of New York, Stony Brook, June 1999, pp. 1-32.

14. Jain P and Gupta S. C, "Hybrid Mixed Handover for Call Blocking Probability Analysis in Wireless ATM Network, *Journal of Engineering and Computer Innovations*, vol. 24, no. 4, April 2011, pp. 68-77.

15. Chenn-Jung H. et al, "A Ratioed Channel Assignment Scheme for Initial and Handoff Calls in Mobile Cellular Systems", *Elsevier Computer Communications* 24, 2001, pages 308-318.

16. Shahriar S.M and Amir H.K, "A Novel Measurement Based Assignment Method: New Priority Method Based on Measurement of Received Power," *1st 2005 International Symposium on Telecommunications*, Sep. 2005, pp.10-12.

17. Fang A and Zhang Y, "Call Admission control Schemes and Performance Analysis in Wireless Mobile Networks," *IEEE Trans. on Veh. Tec.*, vol. 51, no. 2, March, 2002, pp. 371- 382.

18. Onyishi D. U. et al, "Implementation of Static Threshold Schemes in a GPRS Radio Resource Template," *IJECE*, vol. 2, Issue 1, Feb 2013, pp.105-114.

19. Eisenhauer, J. G, "Regression through the Origin," *Teaching Statistics*, vol. 5, no. 3, 2003, pp. 76-80.

20. Uzoagulu A.E. "*Practical Guide to Writing Research Project Reports in Tertiary Institutions*", New Edition, February 2011, pp. 1 – 350.

21. Nidal H. Nasser and Sghaier Guizani, "Analysis of Cell-based Call Admission Control Scheme for QoS Supportin Mutimedia Wireless Networks", *Proceedings of IEEE 16th International Conference on Computer Communications and Network,* 2007,pp. 1250-1254.

22. Pavlidou F, "Mixed Media Cellular Systems", *IEEE Transactions on Communication*, 1994, pp. 848-853.

23. Xiaomin Ma, "Modelling and Performance Analysis for Soft Handoff Schemes in CDMA Cellular Systems", *IEEE Transactions on Vehicular Technology,* Vol.55, No 2, March 2006, pp. 670-680.

24. Muhammed Salamah and Hashem Lababidi, "Dynamically adaptive channel reservation scheme for cellular networks", *Computer Networks* 49 (2005), pp. 787-796.