Performance Assessment of Time-Threshold Based Scheme over Soft Frequency Reuse (SFR) Scheme

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***Abstract*- The Soft Frequency Reuse (SFR) scheme is used to make the cell-edge users get better performance and utilize the resource effectively. Applying Quality of Service (QoS) for cell-edge users in SFR scheme is a challenging issue. Time-Threshold based Scheme (TTS) is a call admission policy that is based on monitoring the elapsed time of the handoff calls and, according to a time threshold parameter, handoff calls are either prioritized or not. In this paper, the performance of SFR scheme in presence of TTS scheme (TTS-SFR) is investigated under different network conditions. The proposed scheme outperforms our previously proposed scheme in terms of handoff dropping (P_d), new call blocking (P_b) probabilities and utilization.**

Keywords - Call Admission Control; Soft Frequency Reuse; Handoff.

I. INTRODUCTION

The tremendous growth of wireless communication and mobile computing needs an ever increasing wireless spectrum. In order to support a number of simultaneous calls at the same time, radio resources have to be reused. Soft Frequency Reuse (SFR) scheme is one of the most promising Inter-Cell Interference Coordination (ICIC) schemes that has been introduced in Long Term Evolution (LTE) -Advanced networks [1]. The SFR scheme divides the available resource blocks (RBs) into two parts: cell-edge RBs and cell-core RBs. Cell-edge users are confined to cell-edge RBs, while cell-core users can access cell-center RBs and cell-edge RBs but with less priority than cell-edge users. This means that cell-center users can use cell-edge RBs only when there are remaining available cell-edge RBs available [1]. In literature, several approaches, such as [2] - [7], have been proposed for the performance analysis of different call admission control (CAC) schemes with SFR. In [2], the impact of new call bounding scheme with SFR using queuing analysis was discussed. In [3], the performance of SFR in presence of Uniform Fractional Guard Channel Scheme (UFGCS) was investigated. A fractional amount of bandwidth unit is allocated for handoff calls. In [4], an adaptive SFR algorithm was developed that dynamically optimizes subcarrier and power allocations for multicell wireless networks to improve system capacity. In [5], a new resource configuration strategy for SFR and an admission control algorithm that takes full account of the frequency planning of SFR was proposed. In [6], the effect of cutoff priority scheme in SFR was investigated using queuing analysis.

Several approaches for CAC schemes, such as [7] -[11], have been discussed to provide priorities to handoff requests and, since it is practically impossible to completely eliminate handoff drops, these schemes have advocated providing probabilistic QoS guarantees by keeping the handoff dropping probability below a certain level. The Guard Channel Scheme (GCS) in [12] gives priority to handoff calls by exclusively reserving channels for handoff calls. Although GCS decreases handoff dropping probability (Pd), it increases new call blocking probability (Pb) and may not utilize the system efficiently. On the other hand, according to the fully shared scheme (FSS), discussed in [12], all available channels in the cell are shared by handoff and new calls. Thus, the FSS scheme minimizes the new call blocking probability and maximizes system utilization. However, it is difficult to guarantee the required dropping probability of handoff calls. Usually, the GCS scheme is preferred by users since it decreases Pd, and the FSS scheme is preferred by service providers, since it maximizes system utilization. As mentioned before, handoff calls are prioritized in many schemes at the expense of blocking newly originating calls. Their claim is "forced termination of ongoing calls is more annoying than blocking of newly originating calls". We believe that this is true to some extent, as the annoyance is a fuzzy term which depends on the elapsed time of the ongoing call [13] - [15]. For example, dropping an ongoing voice call is very annoying if it does not last for a moderate duration, whereas it is not that much annoying if the call is coming to its end. Motivated by these arguments, the current work evaluates the performance of time-threshold based scheme over SFR scheme in terms of P_d , P_b and utilization. The performance of the system is evaluated via extensive simulation. The TTS scheme proposed in [15] is evaluated over SFR scheme. The rest of the paper is organized as follows: Section 2 summarizes the TTS scheme over SFR scheme. In Section 3, simulation parameters are presented. Section 4 presents the performance results. Finally, Section 5 summarizes some key achievements and conclusion.

II. TIME-THRESHOLD BASED SCHEME OVER SOFT FREQUENCY REUSE (SFR) SCHEME (TTS-SFR SCHEME)

In our scheme, we focus on a homogeneous multi-cellular system that has the same arrival times. This allows considering only one cell for performance study. Other cells interact through handoff call arrival process. The cell is divided into edge and core according to the soft frequency scheme.

Figure 1 below shows the flowchart of processing a voice call in TSS scheme over SFR scheme. According to the TTS-SFR scheme, after calculating the number of resource blocks required, the call type is determined. If there is any free RB

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available, then the new call is allocated. For handoff calls that have elapsed real time greater than or equal to time threshold t_e, if the sum of cell-edge RB and cell interior RB is less than total capacity, then the call is accepted. Otherwise, it is dropped. For handoff calls that have elapsed real time less than time threshold t_e, if the sum of cell-edge RB and cell interior RB is less than the total capacity, then the call is accepted. Otherwise, the required resource block is borrowed from a neighbouring new call and the call is accepted. If there are no cells left to borrow from, then the call is dropped.

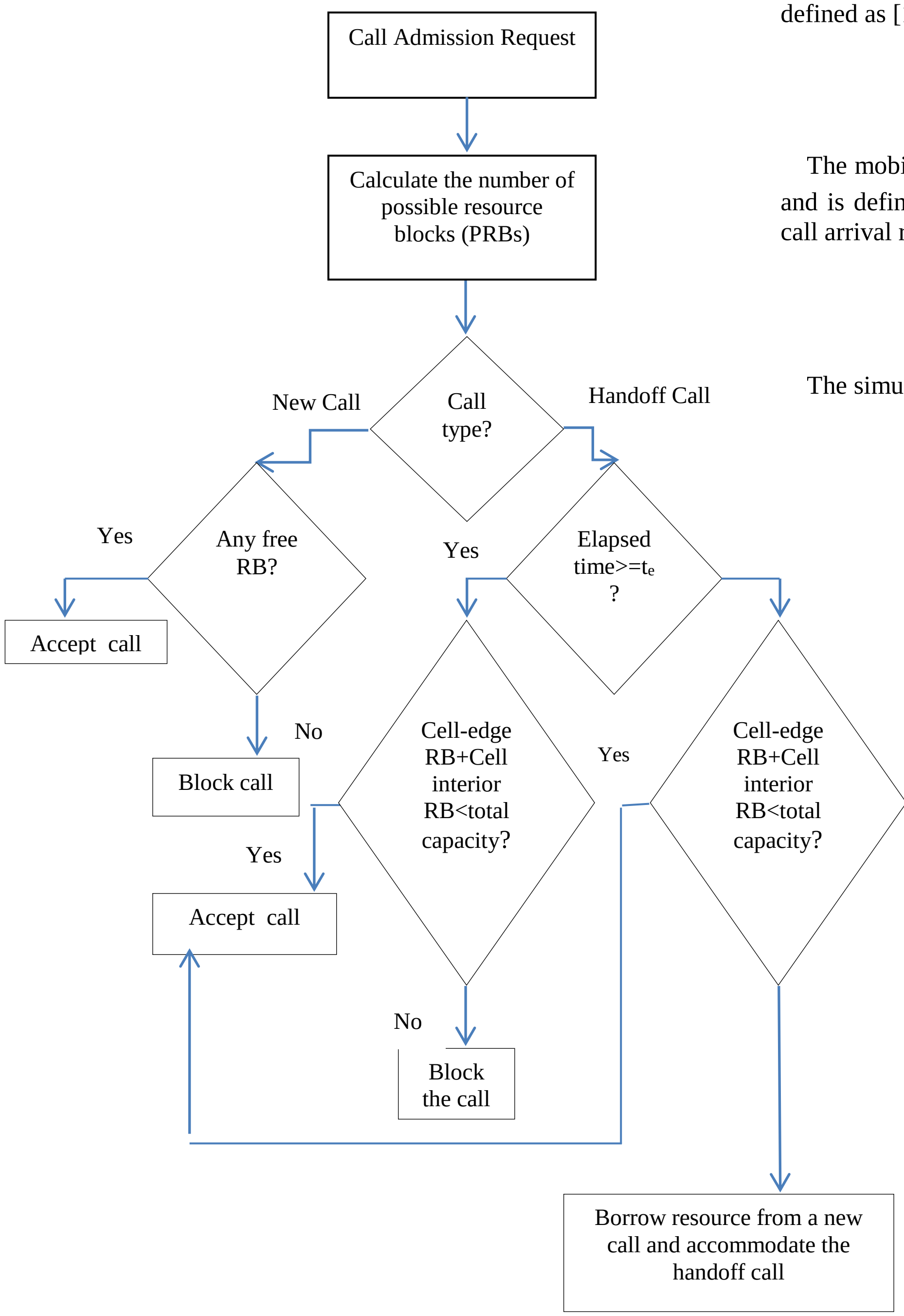

Figure 1. A Call Processing Flowchart

III. SIMULATION PARAMETERS AND PERFORMANCE METRICS

The simulation has been performed using the Java simulation tool [16]. During simulation, more than 30 runs are taken for each point in order to reach 95% confidence level. The inter-arrival times of new voice and handoff voice calls are assumed to follow Poisson processes with means $1/\lambda_n$,$1/\lambda_h$ respectively.

The call holding times follow exponential distribution with means $1/\mu_n$ for new calls, and $1/\mu_h$ for handoff calls.

The normalized offered load of the system (in Erlang) is defined as [12]

$$\rho = \frac{\lambda_n + \lambda_h}{B\mu} \tag{1}$$

The mobility (γ) of calls is a measure of terminal mobility and is defined as the ratio of handoff call arrival rate to new call arrival rate, and can be written as [12]

$$\gamma = \frac{\lambda_h}{\lambda_n} \tag{2}$$

The simulation input parameters used are given in Table 1.

TABLE I
SIMULATION PARAMETERS

Mobility(γ)	0.5, 1, 1.5
Load (ρ)	2 Erlangs
Time threshold values (t_{ev}, t_{ed})	15, 30, 60, 90, 120, 150, and 165 sec.
Total bandwidth (B)	10 MHz(50 RBs,180 kHz per RB)
New call average service time ($1/\mu_n$)	180 sec. (Exp. Dist.)
Handoff call average service time ($1/\mu_h$)	180 sec. (Exp. Dist.)
Average elapsed time of a handoff call	90 sec. (Unif. Dist.)

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IV. PERFORMANCE RESULTS

The proposed scheme is evaluated for different time threshold (t_e) values. The performance measures obtained through the simulation are the blocking probability of new voice calls, the dropping probability of handoff voice calls (P_d) and utilization (U) of the system.

Figure 2 shows the voice handoff call dropping probability (P_d) versus elapsed time threshold (t_e) for mobility=3. It is seen that handoff dropping probability (P_d) decreases as elapsed time threshold (t_e) increases. The reason is that, as t_e increases, resource blocks are borrowed from new calls and handoff calls are accomodated.

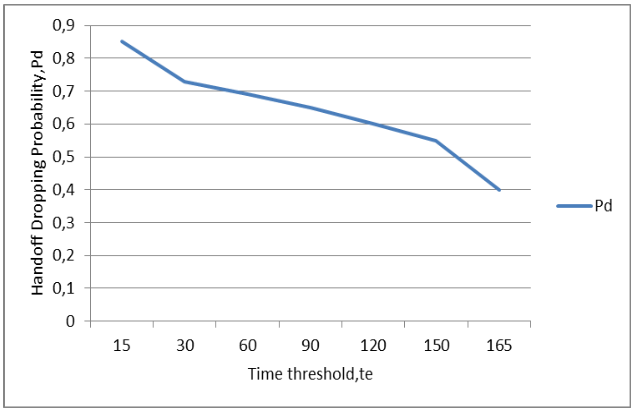

Figure 2. Dropping probability of voice handoff calls (P_d) versus time threshold (t_e) of the TTS-SFR scheme for load=2 and mobility=3

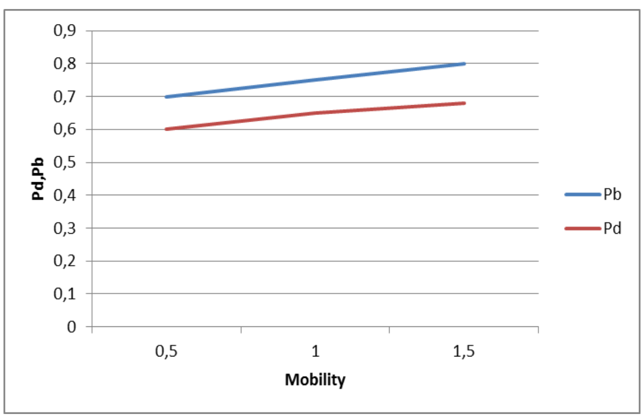

Figure 3. Dropping and blocking probabilities of calls (P_d,P_b) versus mobility of the TTS-SFR scheme for load=2 and te=90 sec

Figure 3 above shows the handoff call dropping probability (P_d) and new call blocking probability versus mobility for elapsed time threshold (t_e) = 90 sec. It is seen that both probabilities increase as mobility increases. This is because, as mobility increases, the number of handoff calls increases and more RBs are borrowed from the new calls.

Figure 4 below shows the blocking, dropping probabilities versus mobility for TTS and TTS-SFR schemes for t_e=90 sec. It is clear that the proposed scheme is superior to the previously proposed TTS scheme in terms of new call blocking and handoff dropping probabilities. In TTS-SFR scheme, if the sum of cell-edge RB and cell interior RB is less than the total capacity, a channel is borrowed from a new call to accommodate handoff call.

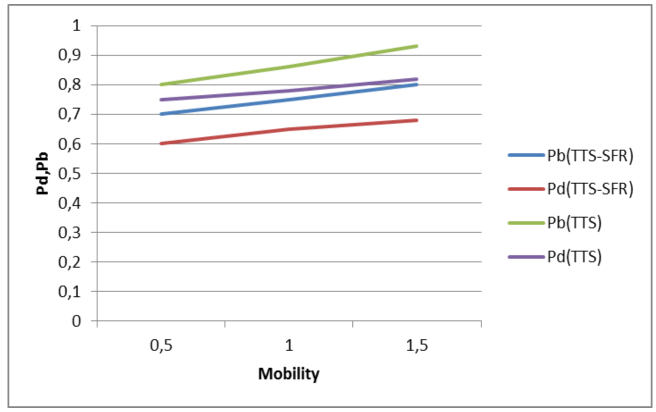

Figure 4. Dropping and blocking probabilities of TTS-SFR and TTS schemes versus mobility

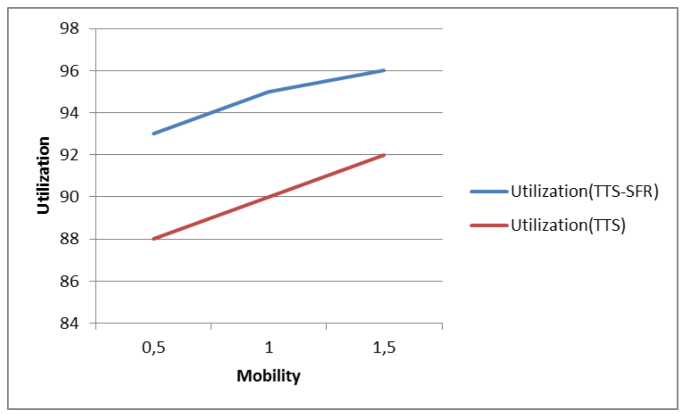

Figure 5. Utilization versus mobility for TTS and TTS-SFR schemes

Figure 5 above shows the utilization versus mobility for TTS and TTS-SFR schemes for t_e=90 sec. TTS-SFR performance is better than TTS in terms of utilization. This means channels are used more efficiently in the TTS-SFR scheme.

V. CONCLUSION

In this paper, a scheme called TTS-SFR is proposed and analyzed under different network conditions. According to the simulation results, the proposed scheme is superior to the previously proposed TTS scheme in terms of new call blocking probability, handoff dropping probability and utilization. There are a number of issues that will be addressed in our future research. We will be including multimedia data and queuing to the proposed model.

REFERENCES

[1] L. Shu, X. Wen, Z. Lin, W. Zheng, Y. Sun, “Queue Analysis of Soft Frequency Reuse Scheme in LTE-Advanced” 2nd International Conference on Computer Modeling and Simulation, pp.248-252, 2010.

[2] M. Safwat, A. Yehya, H. El-motaafy, “Performance Analysis for New Call Bounding Scheme with SFR in LTE-Advanced Networks”, IEEE International Conference on High Performance Computing and Communications, pp.443-451, 2014.

[3] M. Safwat, H. M. El-Badawy, A. Yehya, H. El-Motaafy, “Performance Assessment for LTE-Advanced Networks with Uniform Fractional Guard Channel over Soft Frequency Reuse Scheme”, Wireless Engineering and Technology, 2013, pp.161-170.

[4] M. Quin, W. Hardjawana, Y. Li, B. Vucetic, X. Yang, J. Shi, ”Adaptive Soft Frequency Reuse Scheme for Wireless Cellular Networks”, IEEE Transactions on Vehicular Technology, vol.64, no.1, pp.118-125, Jan 2015.

[5] Z. Lu, H. Tian, Q. Sun, B. Huang, S. Zheng, ”An Admission Control Strategy for Soft Frequency Reuse Deployment of LTE Systems”, 7th IEEE Consumer Communications and Networking Conference, pp.62-66, CCNC 2010.

[6] M. Safwat, H. M. El-Badawy, A. Yehya, H. El-mootaafy, ”Analysis of Cutoff Priority SchemeImpact of Soft Frequency Reuse in LTE-Advanced Networks”, Int.Journal of Scientific & Engineering Research, vol.4, Issue.10, October 2013.

[7] G. S. Kuo, P. C. Ko, M. L. Kuo, "A probabilistic resource estimation and semi-reservation scheme for flow-oriented multimedia wireless networks", *IEEE Communications Magazine*, vol. 39, pp. 135-141, February 2001.

[8] C. Oliveria, J. B. Kim, T. Suda, "An adaptive bandwidth reservation scheme for high-speed multimedia wireless networks", *IEEE J Select. Areas Commun.*, vol. 16, no. 6, pp. 858-874, August 1998.

[9] J. Y. Lee, J. G. Choi, K. Park, S. Bahk, "Realistic cell-oriented adaptive admission control for QoS support in wireless multimedia networks", *IEEE Trans. on Vehicular Tech.*, vol. 52, no. 3, pp. 512-524, May 2003.

[10] I.. Y. Kim, D. Lee, B. Lee, "Dynamic channel reservation based on mobility in wireless ATM networks", *IEEE Communications Magazine*, vol. 37, no. 11, pp. 47-51, November 1999.

[11] Z. Xu, Z. Ye, S. V. Krishnamurthy, S. K. Tripathi, M. Molle, "A new adaptive channel reservation scheme for handoff calls in wireless cellular networks", *Proc. of NETWORKING 2002 Technical Committee “Communications Systems” of International Federation for Information Processing (IFIP-TC6)*, pp. 672-684, May 2002.

[12] I. Katzela and M. Naghshineh, "Channel assignment schemes for cellular mobile telecommunication systems: A comprehensive survey", *IEEE Personal Communications*, pp. 10-31, June 1996.

[13] I. Candan, ”Mobility and Queue Based Guard Channel Scheme for Cellular Networks”, Proc. of 4th International Conference on Wireless Communications, Vehicular Technology,Information Theory and Aerospace/ElectronicSystems, Aalborg,Denmark, pp. 1-4, May 2014.

[14] I. Candan, “A Preemptive Time-Threshold Based Multi-Guard Bandwidth Allocation Scheme for Cellular Networks ”, Proc. of the Sixth Advanced International Conference on Telecommunications,AICT 2010, Barcelona,Spain,May 2010.

[15] I. Candan and M. Salamah, “Analytical Modeling of a Time Threshold Based Bandwidth Allocation Scheme for Cellular Networks”, Computer Communications, vol. 30, no. 5, pp. 1036 1043, 2007.

[16] http://www.um.es./fem/EjsWiki [accessed September 2016]