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Dropping Rate Simulation for a Handover Scheme Using Importance Sampling*

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ABSTRACT

The process of changing the channel associated with the current connection while a call is in progress is under consideration. The estimation of dropping rate in handover process of a one dimensional traffic system is discussed. To reduce the sample size of simulation, dropping calls at base station is considered as rare event and simulated with importance sampling - one of rare event simulation approaches. The simulation results suggest the sample size can be tremendously reduced by using importance sampling.

Keywords: Handover; Importance Sampling; Monte Carlo; Dropping Rate

1. Introduction

Handover is the process of changing the channel (frequency, time slot, spreading code, or combination of them) associated with the current connection while a call is in progress [1]. Usually, continuous service is achieved by supporting handover from one cell to another [2,3]. As shown in **Figure 1**, it is often initiated either by crossing a cell boundary or by deterioration in quality of the signal in the current channel [4].

The handover process starts when the power received by the mobile station from a neighboring cell's base station (BS) exceeds the power received from the BS of the current cell by a certain amount, called handover threshold. This is the threshold in the received power, below which acceptable communication with the BS of the current cell is no longer possible [5]. If the power level from the current BS falls below the receiver threshold prior to the mobile being assigned to a channel by the target BS, the call is terminated and the handover attempt fails.

Queuing priority schemes give possibility to reduce the blocking probability of new calls, where the calls queuing in handover queues. Queuing priority channel assignment strategy is described in [6]. Analysis of a mobile cellular system with handover priority and hysteresis control is given in [7].

Queuing of handover requests is possible, because the mobile station spends some time in handover area, where communications with the current BS decrease in dependence of the speed of moving of the mobile station. Each next request into the handover queue can be served according to certain service discipline.

In nowadays broadband wireless networks probabilistic parameters of Quality of Service (QoS) like probability of dropped calls because all channels at the BS are busy is very small, less than 10^{-9}. In such cases the Monte Carlo simulation, which is implemented for probabilities not less than 10^{-5} [8] is useless and for estimation of handover QoS parameters as blocking probabilities is suggested implementation of rare event simulation.

Rare event simulation helps to speed up the simulation process, as studied probabilistic parameters of quality of service have very small probability between 10^{-8} and 10^{-12}, and they can't be reached with standard Monte Carlo.

2. Modeling of Handover Scheme

A simplified handover mechanism is shown in **Figure 2**,

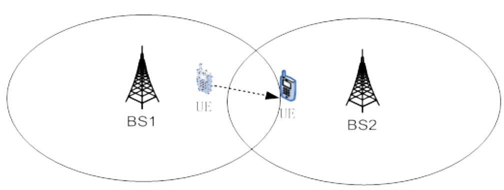

Figure 1. Handover in cell edge.

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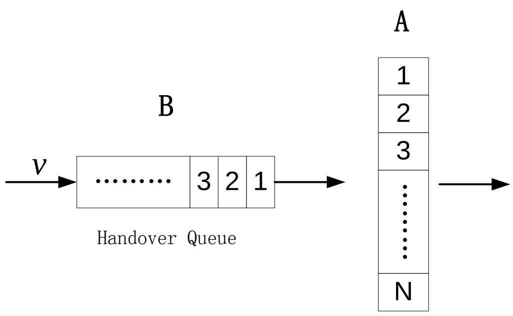

Figure 2. Handover Scheme.

where A is the channel array for BS and B is the handover queue. Here, the number of the BS channels is N, and the hand over traffic coming rate for B is v.

For arbitrary time instant k, denote $a_i(k)$ as

$$a_i(k) = \begin{cases} 1, \text{ the } i\text{-th channel is available} \\ 0, \text{ the } i\text{-th channel is ocuppied} \end{cases} \quad (1)$$

and denote $b_i(k)$ to be the occupied time for the i-th channel till time instant k, $b_i(k) = 1, 2, \cdots$. The numerical relations between $a_i(k+1)$ and $b_i(k)$ can be written as

$$a_i(k+1) = h\left[b_i(k)\right] \quad (2)$$

Usually, when $b_i(k)$ increase, $\Pr\left[a_i(k+1) = 1\right]$ also increase, but unfortunately the closed form solution of h is always hard to achieve.

Let $x(k)$ to be the total number of available channels in time instant k, obviously

$$x(k) = \sum_{i=1}^{N} a_i(k) \quad (3)$$

Let $s(k)$ to be the number of the incoming handover traffic at time instant k, the average coming rate for handover traffic is defined as

$$v = \int s \cdot f(s) ds \quad (4)$$

Here $f(s)$ is the probability density function (PDF) of s.

If $s(k) < x(k)$, all the incoming handover traffic can be allocated with no latency, otherwise, some need to be stored in Queue B temporarily and the number is

$$r(k) = s(k) - x(k) \quad (5)$$

For Queue B, denote $d_j(k)$ to be the waiting time for the j-th element till time instant k. If

$$d_j(k) \geq \alpha \quad (6)$$

the$j$-th handover traffic in Queue B is dropped at time instant k, where α is the dropping threshold. The final question here is to find the average dropping rate under given conditions (included but not limited to N, v, α, $h(\cdot)$, and $f(\cdot)$), but unfortunately the closed form solution is hard to achieve, we always use Monte Carlo simulation to find the numeric results.

3. Monte Carlo Simulation

By Monte Carlo method, the average dropping rate can be estimated as

$$p = \frac{K}{L} \quad (7)$$

Here L is the total number of handover traffic (also called as sample size) and K is the dropped number.

For the l-th sample, define 2-value variable Z_l as

$$Z_l = \begin{cases} 1, \text{ the } l\text{-th sample droped} \\ 0, \text{ else} \end{cases} \quad (8)$$

The average dropping rate p also can be expressed as

$$\hat{p} = \frac{\sum_{l=1}^{L} Z_l}{L} \quad (9)$$

The variance of p can be calculated as

$$\sigma_{\hat{p}}^2 = D\left(\frac{1}{L}\sum_{l=1}^{L} Z_l\right) = \frac{1}{L^2} D\left(\sum_{l=1}^{L} Z_l\right) \quad (10)$$

If all the samples are independent, $\sigma_{\hat{p}}^2$ can be simplified as

$$\sigma_{\hat{p}}^2 = \frac{1}{L^2} \cdot L \cdot D\left(Z_l\right) = \frac{1}{L} \cdot p \cdot (1-p) \approx \frac{p}{L} \quad (11)$$

The accuracy of $\hat{p}$ is always defined as

$$\varepsilon_{\hat{p}} = \frac{\sigma_{\hat{p}}}{p} \quad (12)$$

then

$$\varepsilon_{\hat{p}} = \frac{1}{\sqrt{pL}} = \frac{1}{K} \quad (13)$$

In order to assure the accuracy, for very small p, we need to run large number of L to find enough K, which means large amount of simulation time.

4. Improved Simulation Using Importance Sampling

The most famous approach for rare event simulation is Importance Sampling. Importance Sampling is connected with change the probability density distribution for increasing the frequency of appearance of more “significant” for simulation events.

The basic purpose of this simulation technique is to reduce dispersion or other estimation function, received as a result of computer simulation. During the simulation, process is expected to receive samples proportional of their importance to expected results.

The Importance Sampling estimators can receive in advance given accuracy and in this way the simulation time can be shorten. For generation of significant sample is used limited number of independent variables with normal distribution [9]. Then the conditional probability of appearance of rare event is changed with conditional probability of appearance less rare event with similar distribution [10].

In this research, the average dropping rate p also can be expressed as

$$p = \int q(s) f(s) ds \tag{14}$$

Where $q(s)$ is the probability for certain s.

By using importance sampling, the above equation can be re-expressed as

$$p = \int q(s) f'(s) \frac{f(s)}{f'(s)} ds \tag{15}$$

Here $f'(s)$ is the importance sampling PDF for s, while

$$w(s) = \frac{f(s)}{f'(s)} \tag{16}$$

is the weighting function. Here, s follows negative exponential distribution, and $f'(s)$ is chosen to increase the probability of dropping through change the exponent.

5. Simulation Results

The simulation parameter is shown in **Table 1**. The simulation results between dropping rate p and average handover traffic coming rate v is shown in **Figure 3**. It can be seen p decreases with increasing of v.

The numerical relations between Monte Carlo simulation sample size L_{MC} and average handover traffic coming rate v is shown in **Figure 4**. Here L_{MC} is the least sample size to assure the simulation accuracy of p is smaller than 10%.

Define sample size reduction efficiency as

$$\beta = \frac{L_{MC}}{L_{IS}} \tag{17}$$

the numerical relations between β and average handover traffic coming rate v is shown in **Figure 5**. It can be seen β decreases with increasing of v. Typically, when $v = 0.1$, β approaches to 10^4, which is a tremendous reduction.

6. Conclusions

The processes of changing the radio channel associated with the current connection, while a call in progress is under consideration. A queue handover scheme for broadband mobile communication is suggested.

A simulation approach using importance sampling for estimation of probabilistic parameters of handover dropping rate at broadband wireless networks with rare event estimation is suggested.

Table 1. Simulation parameter.

N	64	$f(\cdot)$	negative exponential distribution
α	3	$h(\cdot)$	negative exponential distribution

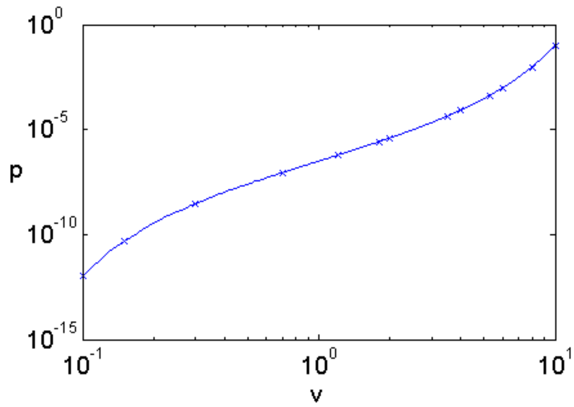

Figure 3. $p \sim v$.

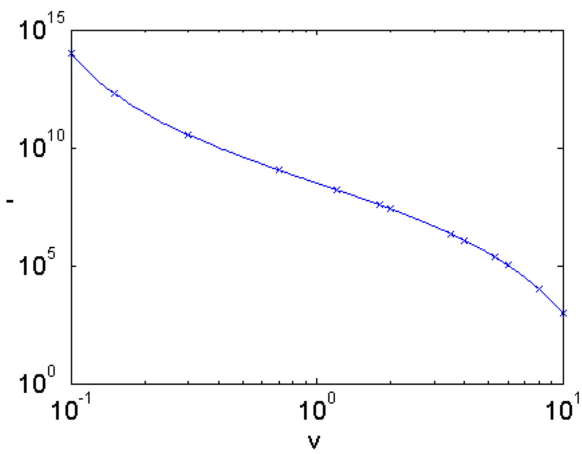

Figure 4. $L_{MC} \sim v$.

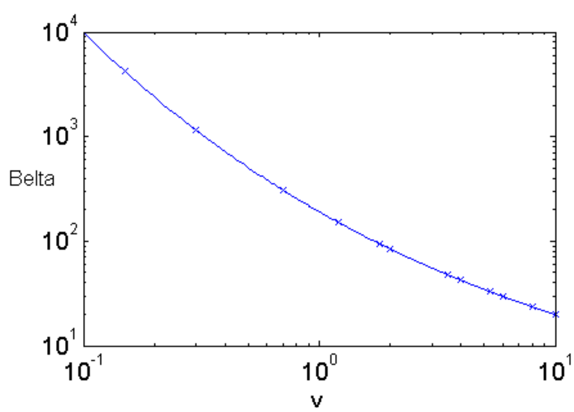

Figure 5. $\beta \sim v$.

The simulation results show that the dropping rate de-decreases with increasing of average handover traffic coming rate *v*. By using importance sampling, the sample size reduction efficiency β decreases with increasing of *v*. typically, when *v* is very small and β approaches a tremendous reduction.

REFERENCES

[1] C. H. M. De Lima, M. Bennis and M. Latva-aho, "Statistical Analysis of Self-Organizing Networks with Biased Cell Association and Interference Avoidance," *IEEE Transac- tions on Vehicular Technology*, Vol. 62, No. 5, 2013, pp. 1950-1961.

[2] Y. Zhang, "Handoff Performance in Wireless Mobile Networks with Unreliable Fading Channel," *IEEE Transactions on Mobile Computing*, Vol. 9, No. 2, 2010, pp. 188-200. http://dx.doi.org/10.1109/TMC.2009.115

[3] Q.-A. Zeng and D. P. Agrawal, "Handoff in Wireless Mobile Networks, Handbook of Wireless Networks and Mobile Computing," John Wiley & Sons, New York, 2002.

[4] H. Kwon, M.-J. Yang, A.-S. Park and S. Venkatesan, "Handover Prediction Strategy for 3G-WLAN Overlay Networks," *IEEE Network Operations and Management Symposium*, NOMS 2008, 2008.

[5] 3GPP TS 23.009: Handover Procedures.

[6] F. Tsvetanov, D. Radev, E. Otsetova-Dudin and S. Radeva, "Rare Event Simulation for a Handover Priority Scheme," 20*th Telecommunications Forum* (*TELFOR*) Belgrade, 20-22 November 2012.

[7] S. Radev and D. Radev, "Modeling of Handover Priority Schemes for Broadband Wireless Networks," *International Journal of Applied Research on Information Technology and Computing* (*IJARITAC*), Vol. 1, No 3, 2010, pp. 322-335. http://dx.doi.org/10.5958/j.0975-8070.1.3.025

[8] J. Bucklew, "An Introduction to Rare Event Simulation. Springer Series in Statistics," Springer-Verlag, Berlin, 2004. http://dx.doi.org/10.1007/978-1-4757-4078-3

[9] E. Ivanova, S. Radeva and D. Radev, "Rare Events and Quality of Services for IPv6 Networks," *Journal of Electro Techniques and Electronics*, Vol. 46 No. 7-8, 2011, pp. 12-17.

[10] A. Masmoudi, F. Bellili, S. Affes and A. Stephenne, "A New Importance-Sampling-Based Non-Data-Aided Maximum Likelihood Time Delay Estimator," *IEEE Wireless Communications and Networking Conference* (*WCNC*), 2011, pp. 1682-1687.

