SIMPLE COMPUTATIONAL PROCEDURES FOR ANALYSIS OF TWO CHANNELS ASSIGNMENT SCHEMES IN WIRELESS COMMUNICATION NETWORKS

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Simple computing procedures to calculate quality of service (QoS) metrics in wireless cellular communication networks at two schemes of the isolated reservation of channels for impatient handover calls are developed. New calls are waiting in finite or infinite queue. Results of numerical experiments are shown.

1. INTRODUCTION

In wireless cellular networks at transfer of mobile speech, the user during transition from particular border cell becomes a handover-call (h-call) to next cell. And if the h-call is accepted in new cell talk resume for it imperceptibly; otherwise there is forced interruption of talk of the given h-call. As h-calls are more sensitive to possible losses and delays, than new calls (o-calls) various schemes of priority service of h-calls are frequently used. These schemes are mainly imply use of reserve channels for h-calls and/or organization of their queue. The detailed bibliography on these problems can be found for example in lists of the literature of works [1, 2].

At the same time, with the purpose of compensate the chances of o-calls it is necessary to organize their queues (finite or infinite length), keeping thus high priority of h-calls at receipt in system which can be provided due to reservation of certain number of radio channels for them. Models of last type were investigated in work [3]. There were investigated four schemes of reservation of channels. It is assumed that cell's radio channels are divided in two disjoint groups and patient o-calls can be served only in the Primary Group while h-calls are served in both groups according to the scheme with pure losses. If during entry of o-call all channels in the Primary Group are busy then received o-call gets in queue. In first two schemes not isolated reservations are offered.

In first from two schemes HRMA (Handoff Reserve Margin Algorithm) initially search of the free channel for service of h-call is carried out in the Primary Group; if all channels of this group are busy, search of the free channel is carried out in the Primary Group. It is assumed that at release the channel of the Primary Group, an h-call served at this moment in the Secondary Group is switched into the Primary Group irrespective of length of queue of o-calls. Unique difference of the second scheme (it's mentioned as HOPSWR - Handoff calls Overflow from Primary to Secondary with Rearrangement) from the first is that here rearrangement of h-call from the Secondary Group to the Primary Group is allowed only when there are no o-calls in queue.

In subsequent two schemes reassignment of h-call from the Secondary Group to the Primary Group is not allowed, i.e. schemes of isolated reservation of channels are suggested. Thus in the third scheme (HOPS - Handoff calls Overflow from Primary to Secondary) initial search of the free channel for service of h-call is carried out in the Primary Group, and in the fourth scheme (HOSP - Handoff calls Overflow from Secondary to Primary) initial search of the free channel for service of h-call is carried out in the Secondary Group.

We should mention that HRMA scheme has been earlier investigated in work [4]. In work [3] for calculation of Quality of Service (QoS) metrics of the HRMA scheme method of generating functions is used and in work [4] for research of HOPSWR scheme the matrix-geometric approach is used. In work [5] precision computing procedures are developed for the approximate calculation of QoS metrics of cells at use of HRMA and HOPSWR schemes for channels allocation.

In present work simple algorithms of calculation of HOPS and HOSP schemes of channels allocation are proposed, thus models with finite and infinite queue of o-calls are considered. These algorithms allow solving the specified problems by means of analytical formulas, thus some of them are even tabulated.

2. SCHEMES OF CHANNELS ALLOCATION

Here model of isolated cell in wireless network which contains the buffer (finite or infinite) only for waiting in queue of o-calls is considered and h-calls are served under the scheme pure losses. It is assumed that o-call (h-calls) received in cells according to Poisson's law with $\lambda_o(\lambda_h)$ intensity and holding time of their service does not depend on call type and is distributed exponentially with mean μ^{-1}. Identity of heterogeneous calls due to duration of their service times is explained with memory less property of exponentially distribution, as if during service of o-call there is handover procedure, remained time of service of current call in new cell (already as h-call) also has exponentially distribution with the same mean.

Scheme of the isolated reservation of channels is used for service of heterogeneous calls. All $m + n$ channels are divided in two disjoint groups: the Primary Group contains m channels and Secondary Group n channels.

Here are considered two schemes of search of free channel for service of received h-call. In both schemes o-calls can be served only in the Primary Group of channels and if during the moment of their entry all channels of this group are busy they become in queue of finite or infinite length. Any conservative discipline of service which does not admit to idle times of channels at presence of queue can be used for service of o-calls queue.

In the first scheme (HOPS) search of the free channel is carried out in Primary Group and if all m channels of this group are occupied, then search of the free channel is carried out in the Secondary Group. In the second scheme (HOSP) search of the free channel is carried out in the Secondary Group and if all n channels of this group are occupied, then search of the free channel is carried out in the Primary Group. In both schemes in cases of occupancy of all $m+n$ channels h-call is lost and any reassignment of h-call from one group to another is not admitted.

3. ALGORITHMS OF QOS CALCULATION OF STUDIED SCHEMES

First of all we shall consider HOPS scheme in model with infinite queue of o-calls. Under its QoS metrics are understood probability of loss of h-calls (P_h), average length of o-calls (L_o) queue also their average latency period in queue (W_o).

The following hierarchical approach can be used for the analysis of this model as in this scheme received h-calls initially go to the Primary Group of channels, and only missed calls of the given type further received in Secondary Group of channels. At the first step of hierarchy we shall consider system with m channels which serve calls of two types with rates λ_o and λ_h, thus holding time of any type call has exponential distribution with common mean μ^{-1}. New calls are buffered in infinite queue and h-calls are lost in case of occupancy of all channels. Missed h-calls are forwarded to the Secondary Group of channels for service.

Consider that the probability of h-calls loss is equal to P_h^1 in Primary Group of channels. Then preceding from property Poisson flow it is concluded that on an input of the Secondary Group of channels proceeds Poisson flow with rate $\widetilde{\lambda}_h := \lambda_h P_h^1$. Hence, on the second stage of hierarchy classical Erlang model with n channels can be considered. The probability of loss of calls in last model will be required P_h. And required sizes L_o and W_o are as result of QoS metrics of queuing system described at the first step of hierarchy.

Now we shall consider task of calculation for specified above QoS metrics. The state of queuing system with two types of calls described at the first step of hierarchy, is given by scalar parameter k which specifies total number of calls in system, $k = 0, 1, 2, \ldots$. Stationary distribution of corresponding birth and death process is set as:

$$\rho_k = \begin{cases} \frac{v^k}{k!}\rho_o & if\ 1 \le k \le m, \\ \frac{v^m}{m!} \cdot \frac{v_o^{k-m}}{m^{k-m}}\rho_o & if\ k \ge m+1, \end{cases} \qquad (1)$$

where $v := \lambda / \mu$, $\lambda := \lambda_o + \lambda_h$, $v_o := \lambda_o / \mu$, $\rho_o = \left(\sum_{k=0}^{m} \frac{v^k}{k!} + \frac{v^m}{m!} \cdot \frac{v_o}{m - v_o} \right)^{-1}$.

At derivation of formulas (1) it turns out intuitively clear and simple condition of ergodicity of models: $v_o < m$. Hence we can see that the condition of ergodicity of models does not depend on loading of handover calls. From (1) it is concluded, that the probability of h-calls loss in the Primary Group (P_h^1) is defined as:

$$P_h^1 = 1 - \sum_{k=0}^{m-1} \rho_k. \qquad (2)$$

Hence, required QoS metric P_h is calculated by means of classical Erlang's B-formula for $M/M/n/0$ model with load of $\widetilde{v_h} := \widetilde{\lambda}_h / \mu$ erl. In other words,

$$P_h = E_B\left(\widetilde{v}_h,\ n\right). \tag{3}$$

where $E_B(\rho, n) = \frac{\rho^n}{n!}\left(\sum_{k=0}^{n} \frac{\rho^k}{k!}\right)^{-1}$.

After the certain transformations we shall get the following formulas for calculation of QoS metric L_o:

$$L_o = \sum_{k=1}^{\infty} k\rho_{k+m} = \frac{v^m}{(m-1)!} \cdot \frac{v_o}{(m-v_o)^2} \cdot \rho_o. \tag{4}$$

QoS metric Wo is got from Little formulas:

$$W_o = L_o / \lambda. \tag{5}$$

Now we shall consider HOSP scheme in model with infinite queue of o-calls. As well as in the previous scheme it is possible to use the hierarchical approach. Here on the first step of hierarchy classical Erlang model $M/M/n/0$ with load $v_h := \lambda_h / \mu$ erl. is considered. Probability of h-calls loss in this model will be denoted through P_h^2, i.e.

$$P_h^2 = E_B(v_h,\ n). \tag{6}$$

Missed h-calls in this system are forwarded to the Primary Group for reception of service. Hence, at the second step of hierarchy the system with m channels which serves calls of two types with rates λ_o and $\widetilde{\lambda}_h := \lambda_h P_h^2$, thus the holding time of call of any type has exponential distribution with general average μ^{-1} is considered. New calls are buffered in infinite queue and in case of occupancy of all channels h-calls are lost. Missed h-calls in this system are finally lost. Thus, stationary distributions of queuing system described on second step of the hierarchy are calculated by means of the formula (1). However in this case in the specified formula parameter λ is determined as $\lambda = \lambda_o + \widetilde{\lambda}$.

Stationary distribution of final system of service will be denoted through ρ_k, $k = 0, 1, 2, \ldots$. The condition of ergodicity of models in the given scheme is also $v_o < m$. Then in view of above-stated, it is concluded that required QoS metric P_h in HOSP scheme of channels distribution is calculated as:

$$P_h = 1 - \sum_{k=0}^{m-1} \rho_k. \tag{7}$$

Other QoS metrics (i.e. L_o and W_o) in given scheme of channels allocation is also calculated from (4) and (5), accordingly. Thus it is necessary to consider that in this case $\lambda = \lambda_o + \widetilde{\lambda}$. The developed method allows defining QoS metrics of the model and at presence of (only) limited buffer for waiting in queue of o-calls. We should note that in these models at any values of loading and structural parameters in system there is stationary mode, i.e. performance of condition of ergodicity is not required $v_o < m$.

4. CONCLUSION

Results of numerical experiments and their analysis are shown in work. Comparative analysis of QoS metrics is lead also at various schemes. Such analysis allows defining suitable scheme of channels allocation proceeding from loading parameters of system and set of restrictions on system QoS metrics. Received results completely coincide with corresponding results of task [3] where for calculation of required QoS metrics complex tool of the theory of multivariate generating functions are used. Moreover, the specified work allows solving these problems only for models with infinite queues of o-calls while the given approach allows defining QoS metrics of system and at presence of finite queue of o-calls.

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