Dynamic Channel Allocation Control with thresholds in Wireless Cellular Networks using Simpy

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ABSTRACT

New and handoff calls control mechanisms are the key point to wireless cellular networks. In this paper, we present an adaptive algorithm for dynamic channel allocation scheme with guard channels and also with handoff calls waiting queue ensuring that handoff calls take priority over new calls. Our goal is to find better tradeoff between handoffs and new calls blocking probabilities in order to achieve more efficient channel utilization. Simpy is a Python based discrete event simulation system. We use Simpy to build our simulation models to get analytical data.

1. INTRODUCTION

In Wireless Cellular Networks it is still an accelerated research to handle handoff calls in an appropriate way. The mobility of subscribers especially at the boundary of cells causes great annoyances [1]. Handoff call dropping, due to lack of wireless resources, gets more concerns than the rejection of a new call—call blocking [2].

A better way to solve this kind of problems is the use of guard channel policy which provides a priority for handoff calls over new calls [3]. Under this policy, a handoff call is admitted as long as there is a free nominal or guard channel, while a new call request is admitted only if there is a free nominal channel. Handoff calls are privileged over new call requests. It is the key point to decide the appropriate number of guard channels in order to minimize the call dropping rate and at the same time to avoid waste of channels by blocking new calls [4]. Due to the variability of traffic load, scheme of dynamically adapting guard channels gains more attention.

In this paper, we present an adaptive algorithm which can dynamically adjust the number of guard channels with some thresholds restraining the handoff calls dropping probability (Pdh), at the same time using handoff calls waiting queue for further ensuring that handoff calls take priority over new calls. We presume that each cell of the network has the same architecture and of same capacity, so we just need to focus on one cell. We compare our methods with fixed guard channel policy as well as no guard channel policy. The numerical results prove that our algorithm can achieve optimal performance—better tradeoff between handoff calls dropping

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probability (Pdh) and new calls blocking probability (Pbn), meanwhile, guarantee higher resource utilization. Simpy is a Python-based discrete event simulation system that models active components such as messages, customers, trucks, planes by parallel processes [5]. We use the popular simulation tool—Simpy to build our simulation models to get analytical data.

The rest of the paper is organized as follows. In Section 2, we discuss the previous work in the literature on channel reservation policy. The system modeling is discussed in Section 3. We give numerical analysis on performance in Section 4, and conclude in Section 5.

2. RELATED WORK

2.1 Handoff Strategies

To improve the quality of service (QoS), various handoff strategies are studied to prioritize handoff calls over new calls, which can mainly fall into two categories: guard channel and handoff queue [6].

The study of guard channels (GC) was first started by Hong and Rappaport [6]. Then an extension of GC considering multiple service types are presented by Li et al [7]. The concept of Multiple Fractional Guard Channel (MFGC) was proposed by Heredia [8]. Those schemes decreased dropping probability of handoff calls to a great extent.

Handoff queue scheme is another commonly used handoffs prioritization strategy which puts the handoff calls in the waiting queue when all channels in a BS are occupied. When a channel is released, the handoff calls in the queue gains the channel prior to a new call [9].

The schemes mentioned above greatly reduce the **Pbh** while sacrificing the **Pbn**. Recent years, various dynamic guard

channel schemes are discussed [4],[10]-[13]. Normally they use thresholds to periodically monitor the **Pbh**, and dynamically adjust the number of guard channels. The aim is to keep the **Pbh** under reasonable limitation meanwhile decreasing as possible the **Pbn** in order to get higher system performance. In this paper, we also monitor the changes of **Pdh** timely to keep it within some limitations (thresholds). We present an adaptive algorithm for guard channel reservation and at the same time adopt a FIFO queue for handoff calls in each BS in order to get better both **Pbh** and **Pbn**.

2.2 General Distribution

In order to construct a more realistic model of Internet traffic sources, we employ self-similar traffic models. Detailed discussion of self-similarity in time series data and the accompanying statistical tests are found in [14]. Normally the time series distributions of self-similar traffic are heavy-tailed, while Pareto distribution is the simplest heavy-tailed distribution. The Pareto distribution is power-law over its entire range, its probability density function is given by [15]:

$$p(x) = \alpha k^{\alpha} x^{-\alpha-1}, \quad \alpha, k > 0, \quad x \geq k.$$

Its distribution function has the form

$$F(x) = P[X \leq x] = 1 - (k/x)^{\alpha}$$

Here k means the smallest possible value of the random variable (location parameter). With α (shape parameter) decreases, a large portion of the probability mass is present in the tail of the distribution. In practical terms a random variable that follows a heavy-tailed distribution can be extremely large values with non-negligible probability. We use Exponential and Pareto distribution to simulate the call arrival rate and the calls service time, respectively.

2.3 Discrete Event Simulation and Simpy

Discrete Event Simulation (DES) was first introduced in the 1950s to solve business problems. It is one way of modeling, simulating, and analyzing a system to observe the behavior of that system. During the simulation process the models are executed over times in order to generate results which are then the basis for future decision making [16][17]. Mechanisms proposed for carrying out DES involve event-based, activity-based, proves-based and three-phase approaches [18].

Simpy is one of discrete events simulation systems based on Python. The simulation is process-oriented, which means that it provides the modeler a number of tools including processes to model active entities, resource facilities (Resources, Levels, and Stores) and ways of recording results [19]. Simpy allows us conveniently and easily to create models of discrete event systems [20].

3. SYSTEM MODELING

As we all know, wireless channel allocation policies may have significant impact on the performance of the system, for example, the new call and handoff calls blocking probabilities, the system utilization, etc. A well-designed policy should take full account of these conditions. We present several kinds of models representing wireless cellular networks with different allocation policies. We then compare our adaptive algorithm with these policies. All the models we've built adopt a handoff call waiting queue for more emphasis on handoffs.

3.1 Policy 1. No Reserved Guard Channels

The kind of model runs like that when a new call (NC) is attempting in a cell covered by a BS, the NC is connected if an idle channel is available in the cell. Otherwise, the new call is blocked. When a handoff call (HC) is moving from one cell to another, it is connected if an idle channel is available in the cell. Otherwise, if the calls waiting queue is not full, it will arranged to the queue waiting for idle channels. If the queue is full, the HC will be dropped.

3.2 Policy 2. Fixed Number of Guard Channels

The kind of models runs like that the processing of new call is similar to the former model. A fixed number of channels exclusively for HCs are reserved as guard channels to reduce the dropping probability of HCs since it is a viral measure of wireless network. Policy 2.1~Policy 2.3 keep 1~3 fixed guard channels respectively. A call waiting queue also kept for handoff calls. According to our former work [21], we get better GoS when taking 2 guard channels. So in these models we choose 1~3 guard channels.

3.3 Policy 3. Adaptive Guard Channels with thresholds

This kind of model runs like the former ones except that the system adjusts the number of guard channels (**g**) automatically according to the current **Pdh**. In this paper, we give the dynamic channel control with thresholds as follows: If the **Pdh** is below the given minimum threshold **Tmin**, which means we needn't keep so many guard channels for handoffs, then the number of guard channels decrease until the current **Pdh** is exceeding the given maximum threshold **Tmax**. Then we need to increase the number of guard channels to make sure it is below the **Tmax**. There are also limitation threshold values for **g**. The value of the **g** is between [**g_min**, **g_max**]. The benefit of this adaptation is that we keep the **Pdh** within some thresholds restriction while the **Pbn** is reduced which can improve the system performance. The algorithm is shown below:

```
if (Arrivals(HC)){
    if (freechannel >0) {
        if (Pdh<Tmin && g>g_min)
            g=g-1;
        else
            if (Pdh>Tmax && g<g_max)
                g=g+1
    }
    else{
        if (HC_queue<MaxQSize)
            HC_queue.append()
        else
            Rejected(HC)
    }
}
```

4. MODEL ANALYSIS

4.1 Measures of Interest

In order to obtain the interested measures numerically from the models, Simpy simulation package is adopted. We consider each cell with a total of 50 free channels and the size of handoffs queue is 3. We assume that all calls arriving process is assumed to be exponentially distributed with mean *Hrate* and *Nrate* for handoffs and new calls respectively, while the call duration is Pareto distributed with the shape parameter α. In the simulation we keep that *Nrate*/*Hrate* = 5/1 and α =1.5.

- NC blocking probability (Pbn)

We get *Pbn* value by calculating the probability:

NRej['new call']/ NArrv['new call']

- HC dropping probability (Pdh)

We get *Pdh* value by calculating the probability:

NRej['handoff']/ NArrv['handoff']

- Grade of Service(GoS)

We then define a formula to represent grade of service for system performance evaluation, *W* is the weight to take use of *Pbn*. Here we let *W*=0.1 in order to focus heavily on HC dropping rate. The formula is as the following:

$$GoS = Pdh + W * Pbn$$

4.2 Input Data

We get the numerical results by giving some different input parameters. Table 1 lists the input data we give to run the simulation. The simulation time is set to be 10000.0 for better accuracy.

Table 1. Input data

Parameter	Meaning	Value
C	Number of total channels	50
g	Number of guard channels	Policy 1: 0 Policy 2.1: 1 Policy 2.2: 2 Policy 2.3: 3 Policy 3: adaptive
Nrate	New call arrival rate	*Nrate/Hrate*=5/1
Hrate	Handoff call arrival rate	
a	Para. of function *paretovariate*()	1.5
Tmax	Upper limit of *Pdh*	0.009
Tmin	Lower limit of *Pdh*	0.006
g_max	Upper limit of g	10
g_min	Lower limit of g	0
W	Weighting factor of GoS	0.1

4.3 Numerical Results

Figure 1 shows different *Pdh* of those models with different new calls arriving rate *Nrate*. We can see that with the number of arriving calls increases, Policy 3 shows best results of *Pdh* than other policies, and with the adaptive function of guard channels it can keep *Pdh* under the threshold limitation.
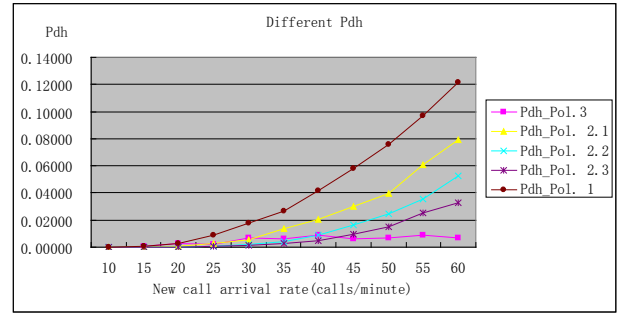

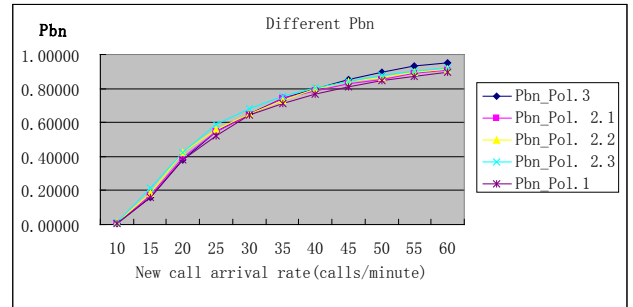Fig. 1. Handoff call dropping probability.
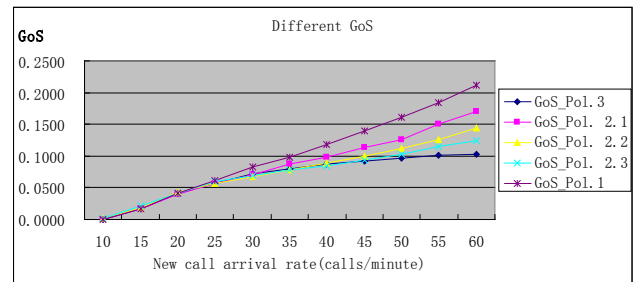

Fig. 2. New call Blocking probability.

Fig. 3. Grade of Service.

Figure 2 shows new call blocking probabilities of those models with different new calls arriving rate *Nrate*. There are very vital differences between those policies. And because Policy 3 gives more priority to handoff calls, certainly it gets a little bit higher values of *Pbn*. Figure 3 shows different *GoS* of those models we calculated with corresponding *Pdh* and *Pbn* values. We can see Policy 3 gets the best system performance. In those figures, Pol.1 means Policy 1, Pol. 2.1 means Policy 2.1, and so on.

As we can see, with the increasing of *Nrate*, handoff calls dropping probability arise correspondingly. Among which Policy 2.3 with more guard channels reserved keeps lowest *Pdh*, while with the expense of highest *Pbn*. For our adaptive algorithm, the *Pdh* are with lower value and can be kept under the given threshold, while the *Pbn* still kept in lower values. So we can get better system performance, like *GoS*.

5. CONCLUSION

In this paper, several channel allocation models with different policies have been constructed to get performance

analysis using Simpy simulation package. We present an adaptive algorithm which aims at keeping balance between *Pdh* and *Pbn* for better system performance. We compare our new model to those models with different allocation policies and analyze their performances such as *Pdh*, *Pbn*, and *GoS* by giving some input parameters. According to the final results we can declare that system using adaptive guard channel policy is more efficient than those other scheduling policies. Our future work will extend this algorithm to add and analyze the utilization of radio resources

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