Dwell Time Modeling for NPS and RCS in WiMAX

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Abstract: Telecom industry experienced a rapid growth and success for past few decades. With the advent of mobile phone, the way of living has changed dramatically. Mobile phone becomes a basic necessity of life. With its vast acceptance, telecom service providers generate a lot of revenue. But to accommodate this vast population with the limited resources is a challenging task. Bandwidth dictates that how much users can be accommodated at a given time. A limited bandwidth means a limited number of users can avail the mobile services. To save the precious bandwidth in order to accommodate more users is the top priority of the telecom service provider. In this paper probability of blocking (Pb), handover failure probability (Ph) and probability of forced termination (Pft) have been depicted. The above mentioned probabilities have been found for two channel allocation schemes namely, Non Prioritized Scheme (NPS) and Reserved Channel Scheme (RCS) in WiMAX. The effect of dwell time has been monitored on each scheme.

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1. Introduction

Entertainment, new ways of conducting businesses and the information sharing make the broadband services as essential as the cellular services. As GSM, due to its low data rates, is not able to provide broadband wireless services so new technologies have to emerge. Shifting of broadband services from the wired lines to the wireless medium is the need of the modern era. WiMAX is a 3G technology which provides the wireless broadband at higher data rates along with cellular services on a common platform. WiMAX provides both (Fixed and Mobile) broadband services. Fixed broadband is an alternative to wired broadband. Mobile broadband provides nomadicity, portability and mobility options.

Wireless medium as compared to wired link is more susceptible to interference. To overcome this problem distinct frequency channels are allocated to each cell. Frequency allocation is done in such a manner that each adjoining cell gets a different frequency band in order to avoid inter-cell interference. These frequency channels form a communication path in a wireless environment. For the allocation of frequency channels to a given cell, a number of channel allocation schemes has been proposed and employed in the past. Some of them are as follow:

Fixed Channel Allocation Scheme (FCA):

A fixed number of channels are allocated to each cell. This technique has a better performance in a low traffic environment such as highway and rural areas.

Dynamic Channel Allocation Scheme (DCA):

In this technique channels are placed in central pool. A cell is given a channel on the request basis from a given pool of channels. A channel is returned to the pool when a user completes the call. This technique is employed in environments having a high traffic such as urban areas [3].

Hybrid Channel Allocation Scheme (HCA):

In this technique a combination of both FCA and DCA is employed. FCA is employed by the users requiring a dedicated connection while DCA is utilized by the users on request basis.

In WiMAX, users along with cellular services also enjoy broadband services. Broadband services require dedicated channel for each broadband user. There are some other channel allocation schemes [2] which are employed in cellular environment.

No Priority Scheme (NPS):

In NPS, there is no priority given to any type of traffic (new call, handover call or a broadband request).

Reserved Channel Allocation Scheme (RCS):

In RCS, a handover call is given more priority than the new call request. Some channels are solely reserved for handover calls. Remaining channels are allocated to both new and handover call requests.

RCS with Permanent Channels:

In this scheme, some channels are available for broadband users which they can utilize for the whole time in order to get uninterrupted service.

2. System Model

A work on deriving analytical method was previously performed for Personal Communication Systems (PCS) [5]. Here work is presented to derive different probabilities in WiMAX including Probability of blocking (Pb), Probability of handover failure (Ph) and Probability of forced termination (Pft).

Probability of blocking (Pb):

The probability that a new call attempt is not entertained and blocked.

Probability of handover failure (Ph):

Handover is required by a user as it leaves the current cell and enters in a new cell. If all the channels in the new cell are busy the handoff request is denied. The probability that a handoff request is denied is the probability of handover failure.

Probability of forced termination (Pft):

A handoff failure in occupying a channel after a successful handoff is the forced termination and the probability that a request is denied due to forced termination is the probability of forced termination.

Different parameters used in Analytical method:

Poisson Distribution:

Poisson distribution is employed for new call requests (cellular call requests or broadband requests) and handover requests.

Channel Occupancy Time:

The time acquired by a new call or a handover request is known as channel occupancy time. This time follows an exponential distribution.

Wireless area is divided into different cells. The traffic flowing in and out of a cell can be represented by different traffic intensities.

- λ_o represents the new call arrival intensity.
- λ_{hi} represents a new handover arrival intensity.
- λ_{hout} represents a new handover departure intensity.

As WiMAX also offers wireless broadband services which is not supported in PCS, another traffic intensity rate should be considered.

- λ_p represents a permanent arrival rate into a cell.

Dwell Time:

The time a user spends in an ongoing call within a cell is the dwell time [1,4]. It is represented by η.

Holding Time:

The total time a user spends including a handover is the holding time. It is represented by μ.

Analytical Method for NPS in WiMAX:

In NPS, as long as there are unused channels any traffic will be given equal priority. NPS follows a Markov Process which includes "s+1" states for a total number of "s" channels. The total intensity of arrived traffic in each state is

$$\lambda = \lambda o + \lambda_p + \lambda_{hi}$$

Each state in the Markov process faces the same intensity of arrived traffic.

The total time for providing the service is the sum of holding and dwell time. The Pb for NPS in WiMAX can be found by using following equation [5]

$$P_b = P_s = \frac{\frac{\left(\frac{\lambda_o + \lambda_{hi} + \lambda_p}{\mu + \eta}\right)^s}{s!}}{\sum_{k=0}^{s} \frac{\left(\frac{\lambda_o + \lambda_{hi} + \lambda_p}{\mu + \eta}\right)^k}{k!}}$$

The handover failure probability in NPS would be same as the blocking probability.

$P_h = P_b$

Analytical Method for RCS in WiMAX:

Consider "s" number of total channels in RCS. The channels occupied for permanent channel requests are represented by "p" and the channels reserved for handover requests are represented by "h".

Then the channels remaining for any type of traffic requests are n, where

n= s – (p + h)

If there are no permanent channels required then

n= s – h

For RCS, the total intensity for arrived traffic for "n" channels in the cell is the sum of new calls arrival intensity, handover and permanent channels intensity.

$$\lambda = \lambda o + \lambda_p + \lambda_{hi}$$

The intensity of traffic arrival rate for "h" channels is λ_{hi} and the traffic intensity for "p" channels is λ_p.

Pj in RCS can be found for three cases [5].

For $0 \le j < n$

$$P_j = \frac{\left(\frac{\lambda_o + \lambda_{hi} + \lambda_p}{\mu + \eta}\right)^j}{j!} P_o$$

For $n \le j < s$

$$P_j = \frac{(\lambda_{hi})^{j-n} (\lambda_o + \lambda_{hi} + \lambda_p)^n}{j!\,(\mu + \eta)^j} P_o$$

For permanent channels and $n \le j < s$

$$P_j = \frac{(\lambda_p)^{j-n} (\lambda_o + \lambda_{hi} + \lambda_p)^n}{j!\,(\mu + \eta)^j} P_o$$

For RCS

$$P_b = \sum_{j=n}^{s} P_j$$

Probability of blocking is found by taking sum of probabilities from state "n" to "s".

Probability of handover failure is given by

$P_h = P_s$

Probability of forced termination is found by using equations presented in [5].

3. Simulation Results

For simulation, total channels are taken to be 50. Out of which 30 are reserved for handover purposes, 10 are reserved for broadband services and mobile requests utilizes the remaining 10 channels. This case is analyzed by changing the dwell time from 2 minutes to 6 minutes.

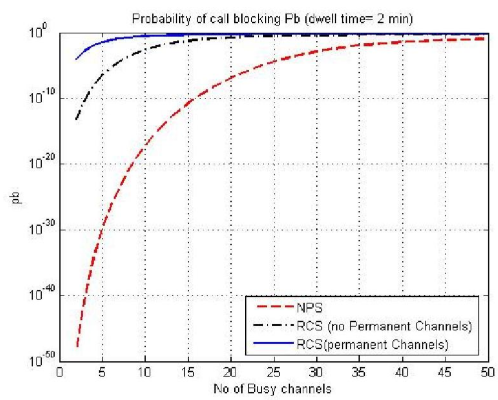

Figure 1.1: Pb Vs No. of Busy Channels (Dwell Time= 2 min)

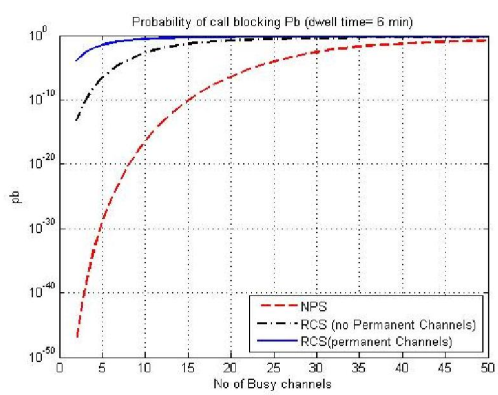

Figure 1.2: Pb Vs No. of Busy Channels (Dwell Time= 6 min)

Probabilities in case for different dwell time values:

Probability of blocking:

There is a slight change on Pb as increased dwell time means less number of handover requests. Less number of handover requests results in a slightly higher channel occupancy time. This increased occupancy time results in slightly higher blocking probability due to unavailability of channels.

Probability of Handover failure:

By increasing dwell time we see that Ph decreases for RCS schemes. This is due to the fact that call remains for a longer time in a cell before a handoff request is made. The more a mobile spends a time in a cell, the lesser the handoff requests are made which results in decreased Ph.

Probability of forced termination:

For RCS, schemes Pft decreases as the dwell time is increased. From here we see that Pft depends upon Ph because it occurs after a successful handoff.

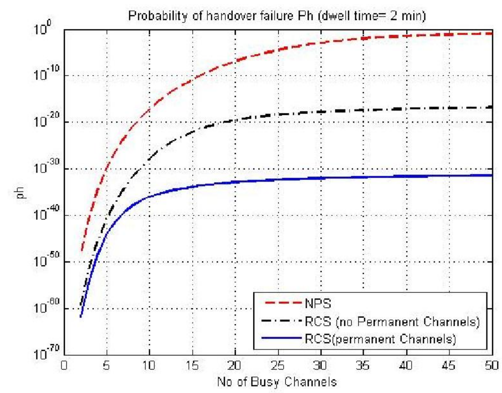

Figure 2.1: Ph Vs No. of Busy Channels (Dwell Time= 2 min)

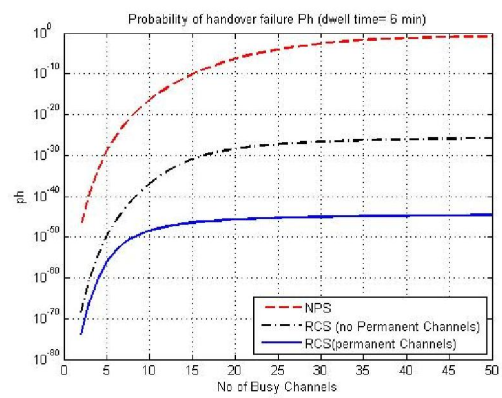

Figure 2.2: Ph Vs No. of Busy Channels (Dwell Time= 6 min)

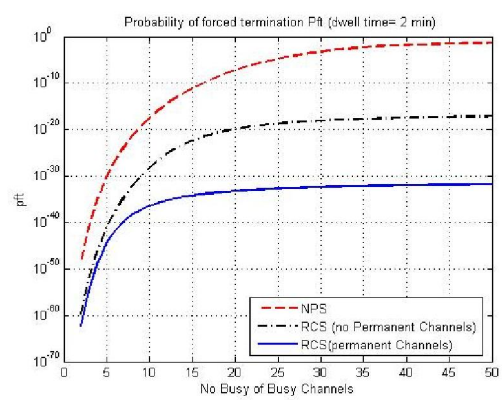

Figure 3.1: Pft Vs No. of Busy Channels (Dwell Time= 2 min)

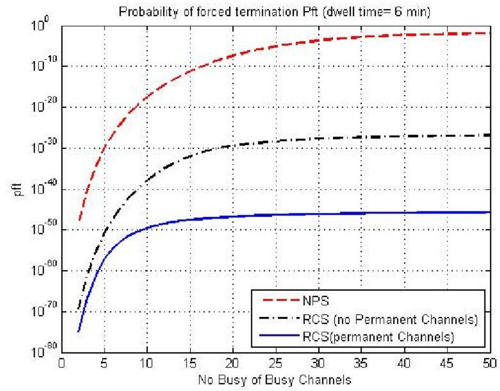

Figure 3.2: Pft Vs No. of Busy Channels (Dwell Time= 6 min)

4. Discussions

Dwell time analysis has been carried out on the above mentioned techniques. By increasing dwell time, the time a user occupy a channel increases which results in lower number of handover requests. Reduction of handover requests results in a decreased Ph in RCS. A greater channel occupancy time means less number of channels available for new calls, so Pb increases in NPS.

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