Mobility Management and Call Admission Control for IEEE802.16e Wireless Networks

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ABSTRACT
The demand for wireless broadband access systems supporting mobility of the individual users has dramatically increased in recent years. Therefore, techniques for dynamically adapting the resources to the link condition become necessary for achieving high spectral efficiency. Our aim in this paper is to develop an admission control scheme that handles the intra-cell mobility issue in IEEE802.16e Wireless Networks with link adaptation. In particular we consider two types of intra-cell mobility: Low-mobility and High-mobility. We show how the admission threshold may adaptively controlled to achieve a better balance between guaranteeing dropping probability and maximizing resource utilization. Simulation results show that the call admission control scheme under different types of mobility outperforms well by reserving amount of resource in order to provide an high priority of migration calls.

Categories and Subject Descriptors
D.2.8 [Software Engineering]: Metrics—performance measures

General Terms
Theory, Performance

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High mobility, Low mobility, CAC

1. INTRODUCTION
With the increasing number of mobile users and the rapid evolution of wireless mobile network, users request in terms of Quality of Service (QoS) become increasingly demanding. Both researchers and industrial actors agree on the massive potential of IEEE802.16 networks as a major communication technology that offers wireless broadband access. Its ability to manage a large spectrum of QoS requirements enables it to carry all metropolitan communication services. As performance, the IEEE society claims an average throughput up to 30 Mbps on a 15 km coverage radius and a mobility speed up to 80 miles/h.

Interested readers are kindly referred to [1] which provides a comprehensive analysis of the standard strengths and weaknesses as compared to other wireless technologies. IEEE802.16e defines five QoS classes [6]: (i) Unsolicited Grant Service (UGS) for constant-bit-rate traffic, delay-and-jitter-sensitive applications such as Voice over IP; (ii) real-time Polling Service (rtPS), also specified for streaming applications but with higher priority on all other classes; (iii) Extended rtPS (ErtPS) adds a bound on the jitter; (iv) non-rtPS (nrtPS) for elastic applications and (v) the traditional Best-Effort (BE). Among the IEEE802.16e specifications, the Adaptive Modulation and Coding (AMC) scheme is undoubtedly the most interesting feature of this standard. There are several existing researches which work on the impact of the AMC scheme on the user mobility management. Concerning the resource allocation, this standard property plays a major role. Call Admission Control (CAC) schemes play an important part in radio resource management. Their aims are to maintain an acceptable QoS to different calls by limiting the number of ongoing calls in the system, minimize the call blocking and dropping probabilities and in the same time efficiently utilize the available resources [2, 3, 4].

In [5], the authors develop the Erlang capacity of OFDMA based WiMAX taking into account the mobility pattern of data users in terms of migration rates between different regions of the cell. Their model of mobility is based on the estimation of spent time that the mobile stays in region before terminates its service.

The authors in [3] propose the performances reached by two CAC algorithms for the OFDMA-based IEEE802.16e (WiMAX) network in presence of two types of traffic: Real-Time (RT) and Best-Effort (BE) including AMC scheme. Considering intra-cell mobility by using a realistic and general mobility model through the Random Waypoint (RWP) approach. In their first CAC scheme, both RT and BE calls
receive the same bit rate independently of the mobile position in the cell. Whereas in the second proposal, only the RT calls receive the same bit rate whatever are the modulation efficiency and the BE calls fairly share the available resources using a Processor Sharing technique. The authors consider only a single class of users mobility in their study.

In this paper, we consider a single IEEE802.16e cell partitioned into \( r \) regions. Each region uses a different modulation and coding technique as described in [6]. Two classes of intra-cell mobility are considered: low mobility and high mobility. For low mobility, the movement of the mobile within the cell is limited and it moves at slow speed and may only migrate to the neighboring regions. For the high mobility, the mobile moves at high speed and it can migrate not only to neighboring regions but may skip one or several regions without changing its modulation. We propose a call admission control scheme that assure to RT calls corresponding to UGS or rtPS classes to receive the same bit rate independently of the mobile position in the cell. In the same time, we introduce a reserving amount of resources in order to provide a high priority of migration calls. We use a Continuous Time Markov Chain (CTMC) to model the system over a decomposition of a single IEEE802.16e cell. We show how the admission threshold may adaptively controlled to achieve a better balance between guaranteeing dropping probability and maximizing resource utilization. Simulation results show that the call admission control scheme under different types of mobility outperforms well by reserving amount of resource in order to provide a high priority of migration calls.

The remainder of this paper is outlined as follows. We describe the model in Section 2. In Section 3, we treat the first CAC mechanism, and the second one is in Section 4. In Section 5, we define the performance metrics which are used to achieve the performance match. In the last, we give some numerical results in Section 6 and end with a concluding summary in Section 7.

2. PROBLEM FORMULATION AND MODEL

In this paper, we desire to relate the user mobility with the channel quality state. Thus we choose to use a path loss model which allows us to consider mean channel quality experienced by mobiles as a function of the distance from the base station. Consequently, the IEEE802.16e cell is decomposed into concentric regions (see Figure 1). Mobiles belong to a region as function of their SNR. They use the modulation schemes and coding rates according with their regions settings. Table 1 provides the regions settings in the IEEE802.16e standard. Let \( R_i \) (\( i = 1, \ldots, r \)) be the radius of the \( i \)-th region and \( S_i \) represents the corresponding surface. Each region corresponds to a specific modulation order (see Table 1). In OFDMA scheme, the total number \( N \) of sub-carriers is divided into \( L \) sub-channels (or groups) each containing \( k \) sub-carriers so that \( k = \frac{N}{L} \). In our study, we consider the multi-services WiMAX/OFDMA system with real-time (RT) traffic. We also define the instantaneous bit rate \( R_{i,RT} \) (radio interface rate) for a call located in the region \( i \) as \( R_{i,RT} = L_{i,RT} \times k \times B \times \varepsilon_i \), where \( k \) is the number of sub-carriers assigned to each sub-channel; \( B \) is the baud rate (symbol/sec); \( \varepsilon_i \) is the modulation efficiency (bits/symbol) and \( L_{i,RT} \) is the sub-channels allowed for region \( i \). The above bit rate can be degraded by the error channel due to collision and shadow fading effect defined in [7] as

\[
R_{i,RT} = \gamma_{i,RT} \times (1 - BLER_i),
\]

where \( BLER_i \) is the Block Error Rate in region \( i \). Table 1 indicates the modulations and codings used in IEEE802.16e cell as function of the user SNR. The SNR requirement for a BLER is less than \( 10^{-6} \) depends on the modulation type as specified in the standard [8]. Then, we have \( \gamma_0 = 24.4 \) dB, \( \gamma_1 = 18.2 \) dB, \( \gamma_3 = 9.4 \) dB, \( \gamma_4 = 6.4 \) dB and \( \gamma_0 = \infty \).

| Table 1: IEEE802.16e AMC settings |
|-------------------------------|---------------|----------------|-----------|
| Modulation | Coding rate | SNR (dB) | Surface (%) |
| 64-QAM | 3/4 | \([\gamma_1, \gamma_0]\) | 1.74 |
| 16-QAM | 3/4 | \([\gamma_2, \gamma_1]\) | 5.14 |
| QPSK | 1/2 | \([\gamma_3, \gamma_2]\) | 20.75 |
| BPSK | 1/2 | \([\gamma_4, \gamma_3]\) | 39.4 |

Figure 1: OFDMA Cell decomposed into concentric regions.

2.1 Intra-cell Mobility Migration

In the intra-cell mobility scenario, the users connected to the same base station have the ability to change their regions (modulation order efficiency) by migration to another one. We suppose a time threshold \( T_{hm} \), which defines the minimum time that a call may remain in a region before the base station changes its modulation and applies to it the specific handover of this region. Let \( T_{hm} \) be a random variable of the time that a mobile will spend in the region \( j \) with the type of mobility \( m \).

- The low mobility \((m = l)\): We consider a class of mobile users moving at relatively low speed denoted by \( V^l \). We assume that \( V^l \in [V_{\min}^l, V_{\max}^l] \). In this scheme, a tagged user in a region \( i \) can terminate its service in the same region \( i \), or he can migrate only from region \( i \) to the neighbor region \( j (j \neq i \pm 1) \) with a probability \( \phi_{i,j} \) such that \( \sum_{i \neq j} \phi_{i,j} = 1 \), e.g., a walker user, cyclist, or car driver in a traffic jam situation. We have the probability \( P(T_{j}^l \geq T_{hm}) \approx 1 \).

- The high mobility \((m = h)\): This illustrates the case where a mobile in region \( i \) moves with speed relatively high \( V^h \in [V_{\min}^h, V_{\max}^h] \). For instance a car driver user in a highway can terminate his service in the region \( i \), or can migrate to some region \( j \) with probability \( \phi_{i,j} \) such that \( \sum_{i \neq j} \phi_{i,j} = 1 \). In fact this user can jump one or more region \( j (|j - i| \geq 1) \) before the base station changes its modulation and run the specific handover related to region \( j \). In order to facilitate this problem, we suppose that a mobile can skip...
3. SYSTEM ANALYSIS FOR THE FIRST CAC MECHANISM

In the first algorithm, we reserve some bandwidth that we can allocate to migration calls without any priority of their types of mobility. So when a new call arrives in the region \( i \), it is accepted if the required resources are available for it. Otherwise the call is blocked. If a call could not finish its service in the region \( i \) and moves to region \( j \neq i \), the call is accepted when the system accepts its modulation changing. The migration call is dropped, if the remaining resources of the system and the reserved resources could not be enough to accept increased bandwidth.

3.1 Equilibrium distribution

The call of RT traffic can come as a new call or migrating/handoff call in region \( i \) from region \( j \). For \( \overline{\pi} \) the current system state, let \( L_m \) be the reserved capacity for migrating or handoff calls and \( L_0 \) denotes the remaining capacity given by \( L_0 = L - L_m \). We define the arrival rate of call in region \( i \) as follows

\[
\lambda_{RT,i,m}^{(\overline{n})} = \begin{cases} 
\lambda_{RT,i}^{(0,m)} + \sum_{j \neq i} \lambda_{RT,j}^{(i,m)}, & \text{if } B(\overline{n}) < L_0; \\
\sum_{j \neq i} \lambda_{RT,j}^{(i,m)} \delta_{i,j}, & \text{if } L_0 \leq B(\overline{n}) < L; \\
0, & \text{otherwise},
\end{cases}
\]

where \( \delta_{i,j} = \begin{cases} 
1, & \text{if } j \geq i; \\
0, & \text{if } j < i.
\end{cases} \)

We can treat two scenarios:

1. We consider that \( L_m = 0 \) which signifies that we can not give a guaranteed service to mobile users changing their regions. So we can accept migration calls if there are available resources, otherwise they are rejected.

2. Another scenario is \( L_m \neq 0 \). We have a guaranteed service to user in mobility.

We recall that we have one class of service: RT call, and two types of mobility (low and high). Each call in region \( i \) with mobility \( m \) requires the effective bandwidth \( L_{RT,i,m} \). Thus we have \( 2r \) classes in the cell, and the equilibrium distribution is given by BCMP theorem [9] for multiple classes with possible class changes with \( \pi^{\overline{n}}_{RT,m} = \frac{\overline{n}^{\overline{n}}}{\overline{n}^{\overline{n}}_{RT,m}} \) as

\[
\pi(\overline{n}) = \frac{1}{G} \prod_{i=1}^{r} \left( \frac{\rho_{RT,i}^{(i,m)}}{n_{RT,i}^{(i,m)}} \right)^{n_{RT,i}^{(i,m)}} \left( \frac{\rho_{RT,i}^{(i,m)}}{n_{RT,i}^{(i,m)}} \right)^{n_{RT,i}^{(i,m)}},
\]

where \( \overline{n} \in E \) and \( G \) is the normalizing constant given by

\[
G = \sum_{\overline{n} \in E} \prod_{i=1}^{r} \left( \frac{\rho_{RT,i}^{(i,m)}}{n_{RT,i}^{(i,m)}} \right)^{n_{RT,i}^{(i,m)}} \left( \frac{\rho_{RT,i}^{(i,m)}}{n_{RT,i}^{(i,m)}} \right)^{n_{RT,i}^{(i,m)}}.
\]

3.2 Calculation of arrival rate of migrating calls

The migration arrival rate of calls from region \( i \) to region \( j \) depends on the marginal expected number of calls in region \( i \). Let \( \rho_{RT,i,m} \) denote the probability that a call needs to migrate into other region from region \( i \) before completing its service in the cell with a mobility \( m \).

We have the closed form expression of this probability as

\[
\rho_{RT,i,m} = \int_0^\infty (1 - e^{-\lambda_{RT,i,m} t}) e^{-\mu t} dt = \frac{\lambda_{RT,i,m}}{\mu + \lambda_{RT,i,m}}.
\]

The \( E[n_{RT,i,m}^{(i,m)}(t)] \) is the marginal expected number of calls with RT service in the region \( i \) for mobility \( m \) and is given by

\[
E[n_{RT,i,m}^{(i,m)}(t)] = \sum_{\overline{n} \in E} n_{RT,i,m}^{(i,m)} \pi(\overline{n}).
\]
Thus the migration function is defined as

$$\lambda_{RT,i,m}(t) = E\{n_{RT,i,m}(t)\}$$

For low mobility, a call migrates from the region $i$ to a neighbor region $j$ ($j = i \pm 1$). The probability that the base station changes the modulation exactly in the region $j$ is $P(T_j^i > T_{Th}) \approx 1$. It signifies that the time spends in the region $j$ is more than the threshold time $T_{Th}$. This probability is given by

$$P(T_j^i > T_{Th}) = e^{-\lambda_{j,i}^1}T_{Th}h,$$

(8)

So we define the arrival rate of migration from region $i$ to region $j = i \pm 1$ with a low mobility as

$$\lambda_{i,j,1}^1 = e^{-\lambda_{j,i}^1}T_{Th}h\delta_{i,j}.\tag{8}$$

For high mobility, the call either migrates from region $i$ to region $j$ ($i \pm 1$) which are similar to the case of low mobility and therefore we use the same probability equation (8), or it migrates to region $j$ ($j = i \pm 2$) and skips $i \pm 1$ region, if the sojourner in $i \pm 1$ region is lower than the time threshold. With a probability $P(T_{Th}^i < T_{Th}) < 1$ and $P(T_{Th}^i + T_{Th}^i > T_{Th}) = 1$, we have

$$P(T_{Th}^i < T_{Th}, T_{Th}^i + T_{Th}^i > T_{Th}) = P(T_{Th}^i < T_{Th})P(T_{Th}^i + T_{Th}^i > T_{Th}),$$

where

$$P(T_{Th}^i < T_{Th}) = 1 - e^{-\nu^1_{i,j}T_{Th}h},$$

and

$$P(T_{Th}^i + T_{Th}^i > T_{Th}) = 1 - \frac{1}{\nu^2_{i,j}T_{Th}h} - \frac{\nu^2_{i,j}T_{Th}h}{e^{-\nu^1_{i,j}T_{Th}h}}.$$

Then the arrival rate of migration from region $i$ to a region $j$ is defined as

$$\lambda_{i,j,1}^1 = e^{-\lambda_{j,i}^1}T_{Th}h\delta_{i,j} + P(T_{Th}^i < T_{Th}, T_{Th}^i + T_{Th}^i > T_{Th})\delta_{i,j},$$

where $j = i \pm 2$. So $\phi_{i,j}^1$ is in the form when the user in region $i$ moves only towards the neighboring region ($j = i \pm 1$) with probability

$$\phi_{i,j}^1 = \begin{cases} 1, & \text{if } i = 1, j = 2; \\ 1, & \text{if } i = r, j = r - 1; \\ 1/2, & \text{if } 2 \leq j \leq r - 1, i = j - 1 \text{ or } i = j + 1; \\ 0, & \text{Otherwise.} \end{cases}$$

As we assume that the user in region $i$ moves to region ($j = i \pm 2$), and skips just one region, so $\phi_{i,j}^2$ will have the form

$$\phi_{i,j}^2 = \begin{cases} 1, & \text{if } i = 1, j = 3; \\ 1, & \text{if } i = 2, j = 4; \\ 1, & \text{if } i = r, j = r - 1; \\ 1, & \text{if } j = r - 1, j = r - 3; \\ 1/2, & \text{if } 3 \leq j \leq r - 2, j = i - 2 \text{ or } j = i + 2; \\ 0, & \text{Otherwise.} \end{cases}$$

Thus the migration function is defined as

$$\lambda_{i,j,1}^{i,m} = \begin{cases} \lambda_{i,j,1}^1, & \text{if } m = 1; \\ \lambda_{i,j,1}^2, & \text{if } m = n. \end{cases}$$

Hence we compute the migration rate ($\lambda_{i,m}^{i,j}, i \neq j$) by using Algorithm 1.

Algorithm 1: Migration arrival rate convergence algorithm

1: Initialize the migration rate by $\lambda_{RT,old,0}^{i,m} = 0$.
2: Calculate the steady state probability $\pi(\pi)$ from (6).
3: Compute the marginal expected number of mobility $m$ from (7).
4: Derive the new values of migration rates denoted by $\lambda_{RT,new}^{i,m}$ from (9).
5: Check the convergence of the migration rates between old rates and new rates, i.e. if $|\lambda_{RT,old}^{i,m} - \lambda_{RT,new}^{i,m}| < \epsilon$ where $\epsilon$ is a very small positive number, then the new migration rates will be used to compute the performance metrics. Otherwise go to step 2 with the new migration rates as initial values and then the iterations are continued until reach the convergence of rates.

4. SYSTEM ANALYSIS FOR THE SECOND CAC MECHANISM

From the first CAC mechanism, we observed that the calls in migration with high mobility ($m = h$) needs more resources than the low mobility ($m = l$) because in our CAC mechanism we have to guarantee the same bit rate anywhere in the cell. Thus a call with high mobility can skip one region before it changes its modulation like as low mobility, so it will be far from the base station and will need more resources in comparison with a call of low mobility. For this reason and in order to have a balance between the two types of mobility and to guarantee the same resources to all calls, we define $\lambda_{RT,old}$ as the reserved capacity for migration or handoff calls of high mobility and $L_0^2$ denotes the remaining capacity given by $L_0^2 = L - L_{high}$. So we give more priority to users in migration with high mobility to guarantee the same bit rate to all calls. Then for the users with low mobility if there are resources available we can accept their migration, otherwise they are rejected. In this state the arrival rate of call in region $i$ with mobility $m$ are defined as

$$\lambda_{RT,new}^{i,m} = \begin{cases} \lambda_{RT,old}^{i,m} + \sum_{j \neq i} \lambda_{RT,old}^{j,m}, & \text{if } B(\pi) < L_0^2; \\ \sum_{j \neq i} \lambda_{RT,old}^{j,m}, & \text{if } L_0^2 \leq B(\pi) < L; \\ \sum_{j \neq i} \lambda_{RT,old}^{j,m} \delta_{i,j}, & \text{otherwise.} \end{cases}$$

(10)

In the same way like as the first CAC mechanism, we define the stationary distribution from equation (6) by using the equation (10) instead of equation (5). We also use the same algorithm to compute the arrival rate of migration calls ($\lambda_{RT,m}^{i,m}, i \neq j$) which is described for the first CAC mechanism.

5. PERFORMANCE METRICS

5.1 Blocking probabilities

A new call of $RT$ service in region $i$ ($i = 1, \ldots, r$) is blocked with probability

$$B_{RT} = \sum_{\pi \in \{\pi\}} \frac{1}{G_{RT}} \prod_{k=1}^{r} \frac{\left(\rho_{RT}^{k,l} B_{RT}^{k,l} + \rho_{RT}^{k,h} B_{RT}^{k,h}\right)}{\left(\rho_{RT}^{k,l} + \rho_{RT}^{k,h}\right)}. \tag{11}$$

where

$$E_{RT} = \{\pi \in \mathbb{E} | B(\pi) + L_{RT} > L_{0}\}$$

with $k = 1$ for the first CAC mechanism and $k = 2$ for the second one. The total blocking probability for all the cell for low and high mobility is defined as

$$P_{cell,RT} = \sum_{i=1}^{r} \lambda_{RT}^{i,m} B_{RT}^{i,m}, \tag{12}$$

where

$$E_{RT} = \{\pi \in \mathbb{E} | B(\pi) + L_{RT} > L_{0}\}.$$
5.2 Dropping probabilities

First CAC mechanism case.

Migrating call dropping probability in region $j$. The migrating call of $RT$ class from region $i$ to region $j$ and as described above for high mobility the mobile may skip more than one region, so we have supposed that $|j-i| < 2$ ($i = 2, \ldots, r$), but for the low mobility it can migrate only to the neighbor regions then we put $j = i \pm 1$, therefore this call is dropped with probability

$$D_{RT}^m(i) = \frac{1}{G} \prod_{k=1}^r \frac{n_{RT}^{k,i} n_{RT}^{k,j}}{n_{RT}^{k,j} n_{RT}^{k,i}},$$

(13)

where

$$E_{RT}^m = \{ \bar{W} \in B(\bar{W}) \mid L_{RT}^i - L_{RT}^j > L \}$$

with

$$F_0 = \{ \bar{W} \in E \mid B(\bar{W}) < L_0 \}$$

and for high mobility a call dropped in region $j$ may come from region $j-1$ or $j-2$, therefore its dropping probability is $\sum_{i=1}^{r-1} D_{RT}^m(i)$.

Thus the dropping probability for a call in region $j$ with mobility $m$ is

$$D_{RT}^m = \begin{cases} D_{RT}^m(i), & \text{if } m = i; \\ \sum_{j=i-2}^{r} D_{RT}^m(t), & \text{if } m = h. \end{cases}$$

(14)

The total dropping probability for all the cell for low and high mobility is

$$PD_{\text{cell,RT}}^m = \sum_{i=2}^{r} \sum_{j=1}^{r-1} \lambda_{RT}^{i,m} D_{RT}^m,$$

$$PD_{\text{cell,RT}}^m = \sum_{i=2}^{r} \sum_{j=1}^{r-1} \lambda_{RT}^{i,m} D_{RT}^m,$$

$$PD_{\text{cell,RT}}^m = \sum_{i=2}^{r} \sum_{j=1}^{r-1} \lambda_{RT}^{i,m} D_{RT}^m.$$
Figure 2: Total blocking probability for all the cell versus threshold $\lambda_{RT}$ and for $L_m = 0$.

Figure 3: Dropping probabilities for low and high mobility versus threshold $\lambda_{RT}$ and for $L_m = 0$, $\lambda_{RT}$.

Figure 4: Total blocking probability for all the cell versus threshold $\lambda_{RT}$, $\lambda_{RT}$, and for $L_m = 0$.

Figure 5: Total blocking probability for all the cell versus threshold $L_m$.

Figure 6: Dropping probabilities versus threshold $L_m$ and for $\lambda_{RT}$, $\lambda_{RT}$, and for $L_m = 0$.

Figure 7: Total dropping probability for all the cell versus threshold $L_m$.

Figure 8: Blocking probabilities for high mobility versus threshold $L_{high}$ and for $\lambda_{RT}^0 = 0.06$.

Figure 9: Dropping probabilities for high mobility versus threshold $L_{high}$ and for $\lambda_{RT}^0 = 0.06$.

Figure 10: Dropping probabilities for low mobility versus threshold $L_{high}$ and for $\lambda_{RT}^0 = 0.06$.

The mean arrival rate of high mobility $\lambda_{RT}$.

The mean arrival rate of low mobility $\lambda_{RT}$.

The mean arrival rate of high mobility $\lambda_{RT}$.

Reserved portion of mobility $L_m$.

Reserved portion for high mobility $L_{high}$.

Reserved portion for high mobility $L_{high}$.
reserved to mobility and found that the dropping probability becomes large because calls in migration are accepted only if there are free resources else they are rejected. In the second scenario, when we took \( L_m = 0 \), the dropping probability becomes weaker as \( L_m \) becomes large and this allows us to guarantee service to users in migration, but on the other hand the new calls are more blocked when \( L_m \) becomes more greater, which help us to appreciate the great impact of the resource reservation on the mobility management efficiency.

**Impact of the second CAC mechanism.**

From the first CAC mechanism, we have remarked that the dropping probability of high mobility calls is higher than the low mobility. This is due to the fact that the high mobility users move more and may skip one region before they change their modulation efficiency. So they need more resources than the low mobility users. And in proximity to guarantee the same quality to all calls, we reserved \( L_{high} \) from the system’s resources which will be intend only to users in migration with high mobility.

As a result, in Figure 8 we present the total blocking probability as function of \( L_{high} \), respectively for high and low mobilities for different modulation efficiency considered in our CAC mechanisms. We observe that the two curves for the same value of \( \lambda _{JT,i} \) for low and high mobility are similar. The causes are already explained above. We also remark that this probability increases when the users become far from the base station and the reserved portion of high mobility calls increases.

Figures 9 and 10 present the dropping probability for high and low mobilities for different modulation efficiency as function of \( L_{high} \). We observe in the first figure that the dropping probability for high mobility decreases when we increase \( L_{high} \) as expected because the calls in migration with this type of mobility use the portion of resources reserved to them. In the second figure, the calls in migration with low mobility must use the remaining portion of resources, so the users with low mobility will be more dropped when \( L_{high} \) becomes more large. We also remark that this probability is more higher for the users far from the base station. Figure 11 depicts the total dropping probability in the whole cell as function of \( L_{high} \). We note that this probability increases when we increase the mean rate of arrival rate especially for low mobility, but for calls with high mobility we observe that even we increase the mean rate of arrival rate this probability decreases when we increase \( L_{high} \).

In the Figure 12, we present the dropping probability for high mobility as function of the mean arrival rate of new calls of high mobility with fixing the value of the mean arrival rate of low mobility. We plot the results for different modulation efficiency in both cases \( L_{high} \) and \( L_m \) in order to make a comparison between the two CAC algorithms. We remark that when we increase the mean arrival rate of high mobility, the dropping probability increases weakly especially for the regions far of the base station which needs more resources in comparison with the regions near to the base station that needs less resources and have a dropping probability nearly null. Also we observe that this probability is more bigger for the first CAC than the second because when we have reserved \( L_{high} \), we give more priority to migration calls with high mobility to benefit of more resources.

In the last Figure 13, we present the same thing as the figure above, but for the low mobility. We note also that the dropping probability augment with the mean arrival rate, and becomes more large for the regions far from the base station. But when we compare the two cases \( (L_{high} \) and \( L_m) \) we observe a remarkable difference. In the first situation, when we reserve \( L_m \) from the resource system, this reserved portion is used by all migration calls (low and high). So the dropping probability in this case is more lower than the situation when we reserved \( L_{high} \), intended only to high probability which increases this probability for the low mobility and decreases it for the high mobility.

7. **CONCLUSION**

In this work we focus on the mobility management especially the intra-cell mobility by devising users according to the operator statistics. The users with high mobility who move with a relatively high speed in the cell and allow them to skip one or more regions before they change their modulation efficiency. The second type users with low mobility who change their modulation just in the neighboring regions. For that we assume a time threshold \( T_{BH} \) which defines the minimum time that a call may remains in a region before the base station changes its modulation and applies to it the specific handover of this region. We compare it with \( T_{BH} \), a random variable that defines the time that the mobile will spend in the region \( j \) with the type of mobility \( m \).

We have proposed two CAC mechanisms. In the first, we have reserved a portion of resources to calls in migration whatever was their type of mobility. And in the second, we have reserved a portion just for the high mobility users because they need more resources. Our objective is to maintain the same bit rate independently of the user position in the cell and their type of mobility, and to permit to users in movement to terminate its communication without being dropped. We have used a continuous time Markov chain which determines the steady state transition probability of the system. We conclude our analysis by characterizing the impact of each CAC mechanism parameters on the system performances. By construing our results we can choose one of the two CAC algorithms according to the politic that likes to follow.

As a future work, we seek to introduce a Random way point approach to find the mean arrival or departure rates into a concentric cell as well as the mean sojourn time in the cellular networks.

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9. REFERENCES


