STUDIA INFORMATICA 2003
Volume 24 Number 4 (56)

Jerzy MARTYNA
Institute of Computer Science, Jagiellonian University

FULLY ADAPTIVE CAC SCHEMES FOR MULTIMEDIA TRAFFIC IN WIRELESS MOBILE NETWORKS

Summary. We introduce adaptive Call Admission Control (CAC) algorithms for micro- and pico-cell wireless multimedia mobile networks. Our approach allows for an arbitrary topology of network. Additionally, we incorporate in our CAC algorithm the required bandwidth, reservation with quality of service and classes of services. The new QoS parameters, such as *Movement Change Ratio*, *Reserved Bandwidth in Neighbouring Cells* and *Possessed Bandwidth in Neighbouring Cells* are derived, allowing for proper tuning of the CAC algorithm. Simulations illustrate the effectiveness of the given algorithms.

Keywords: Call Admission Control, bandwidth reservation, wireless mobile networks

W PEŁNI ADAPTACYJNE SCHEMATY STEROWANIA PRZYJMOWANIEM ZGŁOSZEŃ DLA RUCHU MULTIMEDIALNEGO W BEZPRZEWODOWYCH RUCHOMYCH SIECIACH

Streszczenie. W pracy wprowadzono algorytmy do adaptacyjnego *sterowania przyjmowania zgłoszeń* (CAC) dla bezprzewodowych, multimedialnych sieci radiokomunikacji ruchomej. Dostarczają one wymaganego pasma transmisji, jak również rezerwują je zgodnie z parametrami jakości usług (QoS). W pracy wprowadzono nowe parametry QoS, takie jak *Współczynnik Zmiany Ruchu, Rezerwowane Pasmo Transmisji w Komórkach Sąsiednich, Posiadane Pasmo Transmisji w Komórkach Sąsiednich.*

Słowa kluczowe: algorytmy sterowania przyjmowaniem zgłoszeń, rezerwacja pasma transmisji, bezprzewodowe ruchome sieci

1. Introduction

Personal Communication Service (PCS) networks enable people to communicate independently of their location. The current PCS systems, such as GSM, IS-54 [1, 2], use location management mechanism, which maps all subscribers to the actual location of the requested users. The coverage area of the system is divided into location areas (LA). Each LA consists some groups of cells. The system has the LA information, where the mobile terminal (MT) resides. Whenever an MT crosses an LA boundary, it updates the system with its new location and requirements. PCS networks used currently determine the LA coverage on the basis of static movement probabilities.

Future PCS networks, such as UMTS/IMT-2000, wireless LANs, wireless ATM, etc., are required to support broadband multimedia services with diverse Quality of Service (QoS) requirements. The main solution for supporting the required bandwidth is to reduce the cell sizes [16] and to give back the unused bandwidths. This needs the development of new mobility management schemes for future micro- pico- cellular wireless networks, new Call Admission Control (CAC) algorithms, and new bandwidth reservation methods.

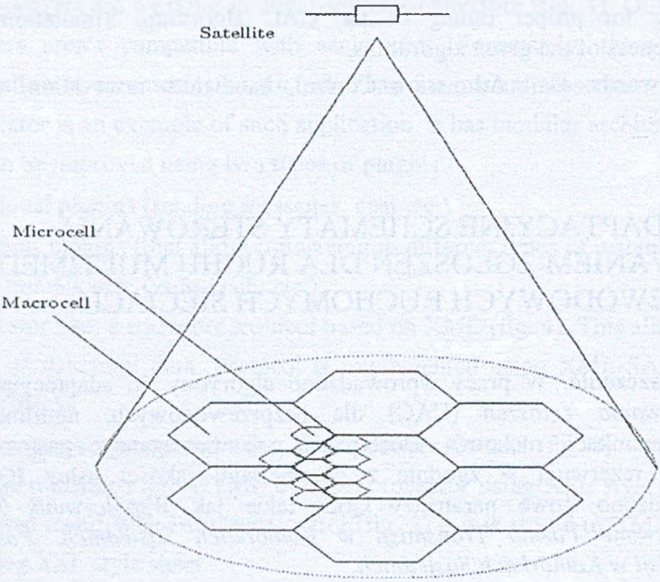

Fig. 1. An example of three-level hierarchical cellular structure
Rys. 1. Przykład trójpoziomowej hierarchicznej struktury komórkowej

Generally, in future wireless mobile multimedia networks, the location area is divided hierarchically into cells, as shown in Fig. 1. In the current technology, the infrastructure of each wireless network consists of three element groups: wireless MTs, MSCs and PSTNs. Each Base Station (BS) serves a group of mobile terminals (MTs) currently residing in a cell.

A mobile Switching Center (MSC) connects all BSs to trunks of the Public Switched Telephone Network (PSTN) or ISDN. Neighbouring MSC can also connect to each other through direct links. The radio link makes the communication between the MT and the Base Station possible. A model of mobile voice communication over Public Switched Telephone Networks is given in Fig. 2.

In order to provide QoS guarantee in a mobile environment, the bandwidth must be divided between all small-sized cells (e.g. micro-cells or pico-cells) [17, 18] to achieve the required transmission capacity. Moreover, the small size of the cells increases the changes in the network traffic and in the provided QoS guarantees [7].

In this paper, we focus in wireless multimedia mobile networks on which proper reservation mechanisms have been provided.

The paper is organized as follows. In the next section, we provide the background and related works implicating our analysis. In section 3, the fully adaptive CAC scheme for multimedia traffic in wireless networks is presented. The simulation model is investigated in Section 4. Finally, we formulate some concluding remarks.

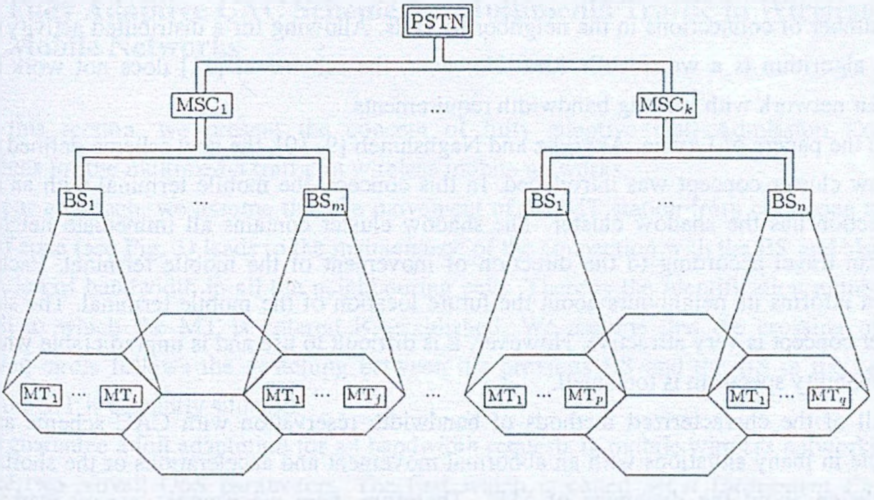

Fig. 2. A model of voice communication over PSTN
Rys. 2. Model transmisji głosowej w publicznej komutowanej sieci telefonicznej (PSTN)

2. Background and Related Works

There are several papers [4, 5, 8] which consider schemes based on dynamic channel (re)assignment in cellular networks. In these schemes, the channels are (re)assigned to different neighbouring cells to reduce interferences and raise the overall system capacity. According to these methods, channels assigned at the beginning to calls may be reallocated to avoid neighboring cells using the same channels. The bandwidth removed from a call is (re)assigned to a new call or to a hand-off call. Although they cannot make admission control, they do not reserve bandwidths for handoff calls either.

The bandwidth reservations for handoff calls to guarantee undisrupted communication are introduced in papers [14, 19, 20]. The joint distinctive mark of these schemes is the reservation of a fixed number of channels in each cell for handoff. The handoff requests are queued in expectation for use. Although these schemes do not consider the desired small call dropping probabilities (due to a higher likelihood that the reserved channels may be not available for handoff calls), they do not adapt to changes in the network traffic loads, either.

In the paper [21] the call admission algorithm for QoS guarantee for an integrated voice and data traffic in the packet radio was given. The CAC algorithm is based on the determined threshold value of either the mean delay or the packet loss probability and on the long-term voice blocking probability. However, the given CAC algorithm does not reserve bandwidth in the neighboring cells.

Naghshineh and Schwartz [11] introduced a distributed admission control scheme based on both the number of existing connections in the cell where the connections are granted and the number of connections in the neighboring cells. Allowing for a distributed activity of the CAC algorithm is a worthwhile idea. However, the scheme in [11] does not work in the cellular network with varying bandwidth requirements.

In the papers of Levine, Akyildiz and Naghshineh [9, 10], the new scheme defined as the shadow cluster concept was introduced. In this concept, the mobile terminal with an active connection has the shadow cluster. The shadow cluster contains all immediate neighbours and can travel according to the direction of movement of the mobile terminal. Each base station informs its neighbours about the future location of the mobile terminal. The shadow cluster concept is very attractive. However, it is difficult to use and is unpredictable when the user mobility spectrum is too small.

All of the characterized methods of bandwidth reservation with CAC scheme are not suitable in many situations with an abnormal movement and accelerations or the shortage of knowledge about the dynamics of MTs. Therefore, here we propose a new method for adaptive CAC algorithms for the multimedia traffic in wireless networks.

In the paper by Oliveira [15] a bandwidth reservation scheme with CAC algorithms for wireless cellular networks was proposed. In this solution, when a new call is accepted, the required bandwidth is allocated in the generating cell and the same bandwidth is also reserved in the immediate neighbouring cells.

The more advanced CAC schemes include the solution given by M.S. Obaidat [13]. In this concept, the rates of traffic flows and resource allocations are monitored. The distributed optimal control was proposed for the guaranteed QoS commitments.

An adaptive, dynamic architecture (DYNAA) was introduced in the paper [12] with the purpose of being in the adaptive multimedia services in wireless mobile networks. The proposed architecture can adapt dynamically to the bandwidth requirement and traffic load. In spite of them, the DYNAA must collaborate with the defined application, which is implemented in the mobile network.

All of the characterized methods of bandwidth reservation with CAC scheme are not suitable in many situations with an abnormal movement and accelerations or the shortage of knowledge about the dynamics of MTs. Therefore, here we propose a new method for adaptive CAC algorithms for the multimedia traffic in wireless networks.

Our call admission control procedures are as follows. In the case of a new call, the procedure *call_arrival* is used to check the available bandwidth in cell *x*. If the desired bandwidth is available, the new call is realized Otherwise, the required bandwidth is borrowed from the neighbouring cells. If the bandwidth isunavailable either in cell *x* or in the neighbouring cells, the call is rejected.

3. Fully Adaptive CAC Scheme for Multimedia Traffic in Wireless Mobile Networks

In this section, we present the concept of fully adaptive Call Admission Control algorithms for the multimedia traffic in wireless mobile networks.

In our approach, we assume that the movement of the MT station from core zone to the handoff zone (see Fig. 3) leads to the maintenance of the connection with the BS and also the reservation of bandwidth in all the neighbouring cells. Thereby the identification number of the cell to which the MT is entered is established. We assume that the crossing of the switching circle follows the switching between the previous BS and the BS in the cell in which the MT is currently situated.

To guarantee a full adaptation for all bandwidth requests in mobile wireless networks, we propose two Novell QoS parameters. The first which is called *MCR* (*Movement Change Ratio*) can take into consideration all change caused by the motion of the MT or user requests. At moment t for each call i the *Movement Change Ratio* is defined as:

$$MCR^{(i)}(t) = \frac{B^{(i)}_{used} - B^{(i)}_{res}(t)}{B^{(i)}_{used}(t)}, \tag{1}$$

where

$B^{(i)}_{used}(t)$ - is the bandwidth used by the call i in the cell,

$B^{(i)}_{res}(t)$ - is the bandwidth reserved by the call i in the neighbouring cells.

In summation of all calls in the cell at moment t, we can obtain two parameters

$$MCR^{(pos)}(t) = \sum_{i=1}^{N_{\max}^{(pos)}(t)} MCR^{(i)}(t) \qquad (2)$$

and

$$MCR^{(neg)}(t) = \sum_{i=1}^{N_{\max}^{(neg)}(t)} MCR^{(i)}(t), \qquad (3)$$

where $N_{\max}^{(pos)}(t)$ is the maximum number of calls which are realized at moment t, and $N_{\max}^{(neg)}(t)$ is the maximum number of calls which are blocked at moment t. The first parameter $MCR^{(neg)}(t)$ indicates the mobility change ratio of the realized calls in the cell, and the second the mobility change of the blocked calls in the cell at moment t.

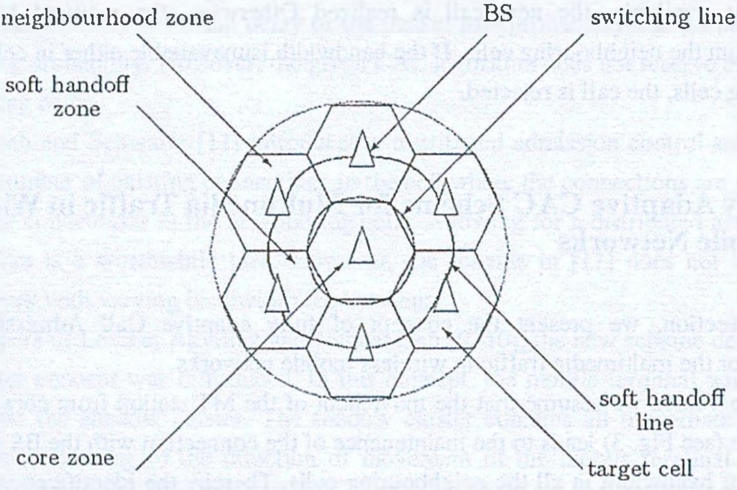

Fig. 3. A concentric geometry for a core zone and its neighbourhood area
Rys. 3. Rozkład przestrzenny dla komórki rdzeniowej i sąsiedniego obszaru

It is obvious that the $MCR^{(i)}(t)$ as a constant value for the i-th call means neither a lack of motion of bandwidth reservation or the movement of the MT with decreasing bandwidth demand and increasing bandwidth reservation in the neighbouring cells. Other situations are also possible. The $MCR^{(i)}(t)$ can grow bigger or grow small. In the first situation the MT will be directed to the BS in the cell. Hence, it must decrease the bandwidth reservation. In the second situation, the MT will retreat from the cell and it must increase the bandwidth. In all the situations the actual parameters of movement are needed. By assumption that BS is in the centre of the coordinate system, we can describe the current position $(x\ ,y)$ of the MT through projections (x_0, y_0) on both axes Ox, Oy.

We propose a *Moving Average of Bandwidth (MAB)* as a second QoS parameter for adaptive multimedia traffic. For the description of the *MAB* parameter we denote the target observation time interval T. Also, let the $MAB(t)$ is defined

$$MAB(t) = \frac{1}{T}\sum_{j=1}^{T} B_{used}^{(i)}(t_j) \tag{4}$$

In our approach, the target observation time interval T is equal to 200 time units.

Using the $MAB(t)$ parameter shown for the observation time interval T, we define a *Bandwidth Band* (BB) as third QoS parameter. Let the $BB_{upp}(t)$ and the $BB_{low}(t)$ denote the upper limitation of required bandwidth and the lower limitation of required bandwidth, respectively. Also define $BB_{upp}(t)$ and $BB_{low}(t)$ to be the bound of the $MAB(t)$ parameter, as defined in the equation (5) and (6). We have:

$$BB_{upp}(t) = MAB(t) + D * \sqrt{\frac{1}{T}\sum_{j=1}^{T}(B_{used}^{(i)}(t_j) - MAB(t))^2} \tag{5}$$

$$BB_{low}(t) = MAB(t) - D * \sqrt{\frac{1}{T}\sum_{j=1}^{T}(B_{used}^{(i)}(t_j) - MAB(t))^2}\,, \tag{6}$$

where D indicates the shift of the $MAB(t)$ upwards and downwards. The interval determines by the both $BB(t)$ parameters is expanded with a large change of the required bandwidth and is narrowed with a little change of required bandwidth.

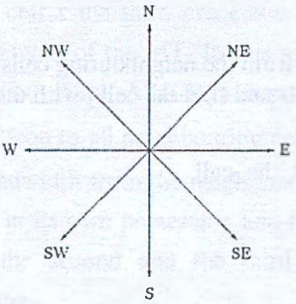

Fig. 4. A wind rose with eight directions
Rys. 4. Różą wiatrów z ośmioma kierunkami

The reserved bandwidth must consider all the neighbouring cells. We propose here the fourth QoS parameter called the *Reserved Bandwidth in Neighbouring Cells (RBNC)*. To define it we propose to use the wind rose with eight directions, namely (clockwise): *N, NE, E, SE, S, SW, W, NW* (see Fig. 4). In more accurate computations, we can use all intermediary directions: *NNE, ENE, ESE, SSE, SSW, WSW, WNW, NNW*. We give for each call i the vector *RBNC*, namely:

$$RBNC^{(i)}(t) = (RBNC^{(i)}_{N}(t), RBNC^{(i)}_{NE}(t), \ldots, RBNC^{(i)}_{NW}(t)) \tag{7}$$

By summation of all $RBNC^{(i)}(t)$ for all calls in the cell at the moment t, we can obtain

$$RBNC(t) = (RBNC_{N}(t), RBNC_{NE}(t), \ldots, RBNC_{NW}(t)) \tag{8}$$

Additionally, the possessed bandwidth is treated as the fifth QoS parameter called the *Possessed Bandwidth in Neighbouring Cells.* To define it we give the following vector:

$$PBNC^{(i)}(t) = (PBNC^{(i)}_{N}(t), PBNC^{(i)}_{NE}(t), \ldots, PBNC^{(i)}_{NW}(t)) \tag{9}$$

By summation of all $PBNC^{(i)}(t)$ for all calls in the cell at the moment t, we can gain

$$PBNC(t) = (PBNC_{N}(t), PBNC_{NE}(t), \ldots, PBNC_{NW}(t)) \tag{10}$$

```
procedure call_arrival(i: integer; $B^{(i)}_{demand}$);
begin
  $B^{(i)} := 0$;
  $F^{(i)}_{avail}(x) = C(x)$;
  $B^{(i)}_{used}(t) := 0$;
  if $B^{(i)}_{demand}(t) \le F_{avail}(x)$ then
    begin
      $B^{(i)}_{used} := B^{(i)}_{used}(t) + B^{(i)}_{demand}$;
      $B_{used}(x) := B_{used}(x) + B^{(i)}_{used}$;
      $F^{(i)}_{avail}(x) := C(x) - B_{used}(x)$;
    end
  else { $B^{(i)}_{demand} > F_{avail}(x)$ }
    begin { borrow the bandwidth from the neighbouring cells }
      { check all neighbouring cells and find the cell j with the most unused bandwidth }
      $\Delta B^{(i)}_{used} := receive\ (\Delta B^{(j)}_{avail})$
      if $B^{(i)}_{demand} \ge B^{(i)}_{used}(x)$ then reject_the_call
      else
        begin
          $B^{(i)}_{used} := B^{(i)}_{used} + \Delta B^{(i)}$;
          $B_{used}(x) := B_{used}(x) + B^{(i)}_{used}$;
          $F_{avail}(x) := C(x) - B_{used}(x)$;
        end
      endif;
    end;
  endif;
end;
```

Fig. 5. Pseudo code of procedure *call_arrival*
Rys. 5. Pseudokod procedury *call_arrival*

The first procedure (see Fig. 5) is used to open the connection for the new call in the cell x. The needed bandwidth must be provided by BS from the accessible bandwidth in the cell. In case there is no bandwidth in the cell, the lacking bandwidth must be borrowed according to the given procedure from the neighbouring cells.

We suppose that after the crossing of the soft handoff line (see Fig. 3), the $\mathrm{RBNC}^{(i)}(t)$ is no more reserved. Hence, the value indicated by $\mathrm{RBNC}^{(i)}(t)$ must be obtained from the accessible bandwidth in the cell in which the MT is located. Hence, the vector PBNC must be also updated (see Fig. 6).

```
procedure soft_handoff_line_crossing( $B_{res}^{(i)}$ );
begin
  $B^{(i)} := B_{res}^{(i)}$;
  for all y = x compute RBNC'(y);
  PBNC(x) := PBNC(x) + RBNC' (y);
  RBNC(y) := RBNC(y) - RBNC' (y);
  for all y ≠ x compute PBNC' (y);
  PBCN(y) := PBCN(y) + PBNC' (x);
  RBNC(x) := RBNC(x) - RBNC' (y);
end;
```

Fig. 6. Pseudo code of procedure *soft_handoff_line_crossing*
Rys. 6. Pseudokod procedury *soft_handoff_line_crossing*

For each mobile terminal in cell x the third procedure *manage_bandwidth in_mobility* (see Fig. 7) is initialized in movement of the MT. In this procedure the change of the first QoS parameter $\Delta MCR(t)$ is studied. If the $\Delta MCR(t)$ is positive, then the call back up the bandwidth is in the proportion of loan to all neighbouring cells. If the change $\Delta MCR(t) \leq 0$, then the call must borrow the bandwidth from the neighbouring cells. In both cases, the call must change the used bandwidth in its own possession and the bandwidth reservation in the neighbouring cells. Therefore, the second and the third QoS parameters are updated according to the direction of moving.

For each motionless mobile terminal in cell x the fourth procedure *manage_bandwidth_in_immobility* (see Fig. 8) is periodically initialized. This procedure allows to reservation of bandwidth according to the directions of the current bandwidth changes.

The fifth procedure (see Fig. 9) is needed to close the connection. The used bandwidth must be back to the unused bandwidth of cell x and to all the neighbouring cells from which it was borrowed.

```
procedure manage_bandwidth_in_mobility;
begin
 if $B_{demand}^{(i)} \le F_{avail}(x)$ then
  begin
  $B_{used}^{(i)} := B_{used}^{(i)} + B_{demand}^{(i)}$;
  $B_{used}(x) := B_{used}(x) + B_{demand}^{(i)}$;
  $\Delta MCR^{(i)}(t) := MCR^{(i)}(t) - MCR^{(i)}(t-1)$
  if $\Delta MCR^{(i)}(t) > 0$ then
   begin
    $\Delta PBNC^{(i)}(t) := PBNC^{(i)}(t-1) - PBNC^{(i)}(t)$;
    { give back the bandwidth $\Delta PNBC^{(i)}(t)$ in proportion of borrow }
    $RBNC^{(i)}(t) := RBNC^{(i)}(t) - \Delta PBNC^{(i)}(t)$;
   end;
  else { $\Delta MCR^{(i)}(t) \le 0$ }
   begin
    $\Delta PBNC^{(i)}(t) := PBNC^{(i)}(t-1) - PBNC^{(i)}(t)$
    { borrow the bandwidth $\Delta PBNC^{(i)}(t)$ according to direction of movement }
    $\Delta RBNC^{(i)}(t) := RBNC^{(i)}(t) - \Delta PBNC^{(i)}(t)$;
   end;
  endif;
 end;
 endif;
end;
```

Fig. 7. Pseudo code of procedure *manage_bandwidth_in_mobility*
Rys. 7. Pseudokod procedury *manage_bandwidth_in_mobility*

4. Performance Study

In this section, we present simulation results to shown how the given CAC procedures satisfy the QoS parameters for multimedia traffic in wireless system. We assumed the following parameters of simulation. The bandwidth capacity of each cell is equal to 10000 units. Minimum 10 units are required in order to realize the call. The maximum bandwidth allowed for the call is equal to 100 units. We assumed that twenty percent of total calls are moving in the given time slot. Additionally, twenty-five percent of calls are terminated in each time slot.

```
procedure manage_bandwidth_in_immobility;
begin
 if $B^{(i)}_{demand} \le F_{avail}(x)$ then
  begin
   $B^{(i)}_{used} := B^{(i)}_{used} + B^{(i)}_{demand}$;
   $B_{used}(x) := B_{used}(x) + B^{(i)}_{demand}$;        { give back the bandwidth }
   $\Delta BB^{(i)}_{upp}(t) := BB^{(i)}_{upp}(t) - \Delta BB^{(i)}_{upp}(t-1)$;
   $\Delta BB^{(i)}_{low}(t) := BB^{(i)}_{low}(t) - \Delta BB^{(i)}_{low}(t-1)$; { make reservation of bandwidth }
   $RBNC^{(i)}(t) := RBNC^{(i)}(t) - \Delta BB^{(i)}_{upp}(t)$;   { back up the bandwidth }
   $PBNC^{(i)}(t) := PBNC^{(i)}(t) - \Delta BB^{(i)}_{low}(t)$;
  end;
 else { borrow the bandwidth from neighbouring cells }
  begin
   $B^{(i)}_{demand} := B_{borrow}$;
   $B^{(i)}_{used} := B(i)^{(i)}_{used} + B^{(i)}_{demand}$;
   $\Delta BB^{(i)}_{upp}(t) := BB^{(i)}_{upp}(t) - BB^{(i)}_{upp}(t-1)$;
   $\Delta BB^{(i)}_{low}(t) := BB^{(i)}_{low}(t) - BB^{(i)}_{low}(t-1)$;   { make reservation of bandwidth }
   $RBNC^{(i)}(t) := RBNC^{(i)}(t) - \Delta BB^{(i)}_{upp}(t)$  end;
 endif;
end;
```

Fig. 8. Pseudo code of procedure *manage_bandwidth_in_immobility*
Rys. 8. Pseudokod procedury *manage_bandwidth_in_inmobility*

In the simulation, we assumed that all call requests arrive according to the Poisson distribution. The service time (call holding time) is exponentially distributed.

We performed simulation to compare the given CAC procedures with multimedia and non-multimedia services. We assumed that in non-multimedia services, the new call is realized if the bandwidth is required without the introduced QoS parameters.

```
procedure call_departure( $B^{(i)}_{deliver}$ );
begin
 $B^{(i)}_{deliver}$ := departure($B^{(i)}$);
 for all $y \neq x$ compute PBNC' and RBNC';
 PBNC(y) := PBNC(y) + PBNC'(y);
 RBNC(y) := RBNC(y) - RBNC'(y);
 for all $y = x$ compute PBNC'(y) and RBNC'(y);
 PBNC(x) := PBNC(x) + PBNC'(y);
 RBNC(x) := RBNC(x) - RBNC'(y);
end;
```

Fig. 9. Pseudo code of procedure *call_departure*
Rys. 9. Pseudokod procedury *call_departure*

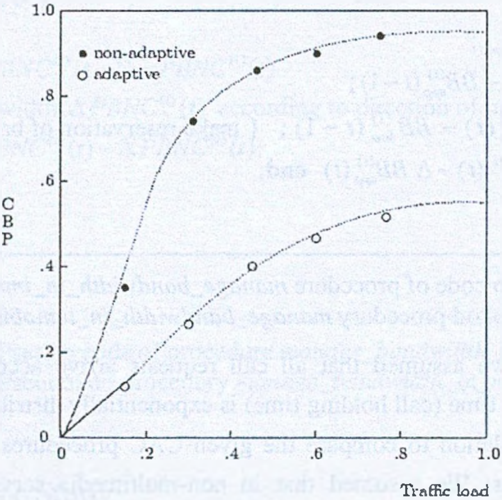

Fig. 10. Call Blocking Probability (CBP) versus traffic load for multimedia and non-multimedia traffic
Rys. 10. Prawdopodobieństwo blokowania się połączenia w zależności od obciążenia dla ruchu multimedialnego i niemultimedialnego

The mobility pattern was chosen as follows. The user is allowed to move anywhere he wants. It was chosen at a random value x in the range [0, 2] with the uniform probability distribution, as given:

In our simulation we studied the call blocking probability (CBP) and the probability of a handoff arriving call being dropped (HDP) for adaptive and non-adaptive traffic in the load dependence. We suppose that the rate of the call handoff to another cell, λ_h, is proportional to the new call arrival rate, namely $\lambda_h = \beta \lambda_n$.

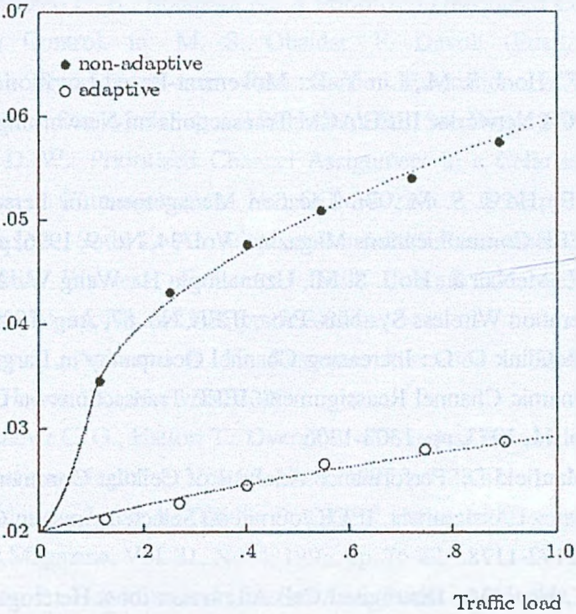

Fig. 11. Handoff Dropping Probability (HDP) versus traffic load for multimedia and non-multimedia traffic

Rys. 11. Prawdopodobieństwo zerwania przenoszenia połączenia w zależności od obciążenia dla ruchu multimedialnego i niemultimedialnego

The preliminary results are depicted in the Figs. 10-11. Figure 10 show the CBP versus the load of the traffic for adaptive and non-adaptive multimedia traffic. Figure 11 show the HDP versus the load of traffic for adaptive and non-adaptive traffic. We can see that the given CAC procedures adapt to the multimedia traffic better than the non-adaptive traffic.

5. Concluding Remarks

We have developed fully adaptive CAC schemes for the multimedia traffic in mobile wireless networks. Such fully adaptive procedures are not only of primary importance, but have useful practical implications as well. For instance, it obviates the need to come up, among others, with a new intelligent antenna for wireless communications. Our theoretical analysis is useful for predicting how the CAC schemes will perform in the case each problem with movement. Our simulation study shows that the investigation appears worthwhile, especially under bandwidth changes. To this end, we will compare our CAC schemes to other solutions, for instance to the reservation-based schemes presented in [15] and [6]. In future, we will extend our schemes to the networks that support multiple classes of adaptive multimedia.

REFERENCES

1. Akyildiz I. F., Ho J. S. M., Lin Y.-B.: Movement-Based Location Update and Selective Paging for PCS Networks. IEEE/ACM Transactions on Networking, Vol. 4, No. 4, 1996, pp. 629-638.
2. Akyildiz I. F., Ho J. S. M.: On Location Management for Personal Commu-nication Networks. IEEE Communications Magazine, Vol. 34, No. 9, 1996, pp. 138-145.
3. Akyildiz I. F., McNair J., Ho J. S. M., Uzunalioglu H., Wang W.: Mobility Management in Next Generation Wireless Systems. Proc. IEEE, No. 87, Aug. 1999, pp. 1347-1384.
4. Cox D. C., Reudink D. O.: Increasing Channel Occupancy in Large-Scale Mobile Radio Systems: Dynamic Channel Reassignment. IEEE Transactions on Communications, Vol. COM-21, No. 11, 1973, pp. 1303-1306.
5. Everitt D., Manfield D.: Performance Analysis of Cellular Communication Systems with Dynamic Channel Assignment. IEEE Journal on Selected Areas in Commun., Vol. 7, No. 9, 1989, pp. 1172-1178.
6. Haung Y.-R., Ho J.-M.: Distributed Call Admission for a Heterogeneous PCS Network. IEEE Transactions on Computers, Vol. C-51, No. 12, 2002, pp. 1400-1409.
7. Jabbari B., Colombo G., Nakajima A., Kulkarni J.: Network Issues for Wireless Communications. IEEE Communications Magazine, Vol. 33, No. 1, 1995, pp. 88-99.
8. Katzela I., Naghshineh M.: Channel Assignment Schemes for Cellular Mobile Telecommunication Systems: A Comprehensive Survey. IEEE Personal Communications, June 1996, pp. 10-31.
9. Levine D. A., Akyildiz I. F., Naghshineh M.: The Shadow Cluster Concept for Resource Allocation and Call Admission in ATM-Based Wireless Networks. in: MOBICOM'95 Proceedings of the First Annual International Conference on Mobile Computing and Networking, ACM 1995, New York, N.Y., pp. 142-150.
10. Levine D. A., Akyildiz I. F., Naghshineh M.: A Resource Estimation and Call Admission Algorithm for Wireless Multimedia Networks Using the Shadow Cluster Concept. IEEE/ACM Transactions Networking, Vol. 5, 1997, pp. 1 - 12.
11. Naghshineh M., Schwartz M.: Distributed Call Admission Control in Mobile/Wireless Networks. IEEE Journal on Selected Areas in Communications, Vol. 14, No. 4, 1996, pp. 711-717.
12. Naja R., Tohme S.: Adaptive QoS and Handover Issues in Wireless Multimedia Networks Using a Dynamic Adaptive Architecture: DYNAA. in: C.G. Omidyar (Ed.): Mobile and Wireless Communications, Kluwer Academic Publishers, Norwell 2003, pp. 133-140.

13. Obaidat M. S., Ahmed C. B., Boudriga N.: A Prioritized Distributed Control Scheme for Call Admission Control. in: M. S. Obaidat, F. Davoli (Eds.), Proceedings of 2001International Symposium on Performance Evaluation of Computer and Telecommunications, Soc. Modeling and Simulation Int., San Diego 2001, pp. 399-405.
14. Oh S.-H., Tcha D.-W.: Prioritized Channel Assignment in a Cellular Radio Network. IEEE Transactions on Communications, Vol. COM-40, No. 7, 1992, pp. 1259-1269.
15. Oliveira C., Kim J. B., Suda T.: An Adaptive Bandwidth Reservation Scheme for High-Speed Multimedia Wireless Networks. IEEE Journal on Selected Areas in Communications, Vol. 16, No. 8, 1998, pp. 858-874.
16. Ortigoza-Guerrero L., Aghvami A. H.: Resource Allocation in Hierarchical Cellular Systems. Artech House, Inc., Norwood 2000.
17. Pabgett J. E., Gunther C. G., Hattori T.: Overview of Wireless Personal Communications. IEEE Communications Magazine, Vol. 33, No. 1, 1995, pp. 28-41.
18. Sarnecki J., Vinodrai C., Javed A., O'Kelly P., Dick K.: Microcell Design Principles. IEEE Communications Magazine, Vol. 31, No. 4, 1993, pp. 76-82.
19. Tekinay S., Jabbari B.: Handover and Channel Assignment in Mobile Cellular Networks. IEEE Communications Magazine, Vol. 29, No. 11, 1991, pp. 42-46.
20. Tekinay S., Jabbari B.: A Measurement-Based Prioritization Scheme for Handover in Mobile Cellular Networks. IEEE Journal on Selected Areas in Communications, Vol. 10, No. 8, 1992, pp. 1343-1350.
21. Yang W.-B., Geraniotis E.: Admission Policies for Integrated Voice and Data Traffic in CDMA Packet Radio Networks. IEEE Journal on Selected Areas in Communications, Vol. 12, No. 4, 1994, pp. 654-664.

Recenzent: Dr inż. Bartłomiej Zieliński

Wpłynęło do Redakcji 28 kwietnia 2003 r.

Omówienie

W pracy wprowadzono nowe algorytmy *sterowania przyjmowaniem zgłoszeń* (CAC) dla bezprzewodowych, multimedialnych sieci radiokomunikacji ruchomej. Dostarczają one wymagane pasmo transmisji oraz pozwalają na jego rezerwację, co ma miejsce w przypadku ruchu stacji ruchomej. W pracy zostały wprowadzone nowe *parametry jakości usług* (QoS), takie jak: *Współczynnik Zmiany Ruchu* (MCR) (wzór 1), *Średnia Ruchoma Pasma Transmisji* (MAB) (wzór 4), *Wstęga Pasma Transmisji* (BB) (wzory (5) i (6)). Czwartym i piątym para-metrem (QoS) są odpowiednio: *Rezerwowane Pasma Transmisji w Komórkach Sąsiednich* (RBNC) (wzór (8)) oraz *Posiadane Pasmo Transmisji w Komórkach Sąsiednich* (PBNC) (wzór (10)). Algorytmy CAC stanowią procedury dotyczące m.in.: otwarcia połączenia, zamknięcia połączenia, zarządzania pasmem transmisji w przypadku braku ruch stacji ruchomej, zarządzania pasmem transmisji w przypadku ruchu stacji ruchomej. Wyniki badań symula-cyjnych potwierdzają przydatność opracowanych algorytmów CAC. Uzyskano w nich m.in. *prawdopodobieństwo blokowania się połączenia* (CBP) (rys. 10) oraz *prawdopodobieństwo zerwania przenoszenia połączenia* (HDP) (rys. 11) dla ruchu multimedialnego i niemultime-dialnego w zależności od obciążenia.

Adres

Jerzy MARTYNA: Institute of Computer Science, Jagiellonian University, Nawojki 11, 30-072 Kraków, Poland, martyna@softlab.ii.uj.edu.pl