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Clique Packing Approximation for Analysis of Teletraffic Characteristics of Dynamic Channel Assignment Considering Mobility

Heun-Soo LEE[†], ***Student Member***, **Naoyuki KARASAWA**[††a)], **Keisuke NAKANO**[††], ***and*** **Masakazu SENGOKU**[††], ***Regular Members***

SUMMARY This paper discusses the teletraffic characteristics of cellular systems using Dynamic Channel Assignment. In general, it is difficult to exactly and theoretically analyze the teletraffic characteristics of Dynamic Channel Assignment. Also, it is not easy to theoretically evaluate influence of mobility on the traffic characteristics. This paper proposes approximate techniques to analyze teletraffic characteristics of Dynamic Channel Assignment considering mobility. The proposed techniques are based on Clique Packing approximation.

key words: *cellular system, dynamic channel assignment, clique packing, hand-off, teletraffic characteristics*

1. Introduction

In cellular mobile communication systems [1], a service area is divided into a lot of small zones, which are called cells. When FDMA is used, a channel is simultaneously assigned to some cells by channel assignment algorithms avoiding co-channel interference. Hence, performance of channel assignment algorithms affects the efficiency of channel utilization. Most of all channel assignment algorithms are classified into Fixed Channel Assignment (FCA) or Dynamic Channel Assignment (DCA). In cellular systems using FCA, the number of channels assigned to a cell is constant; therefore, such systems can be modeled by full-availability systems. Consequently, the blocking probability in a cell can be calculated by using the Erlang B formula if it is assumed that terminals do not move. On the other hand, in cellular systems using DCA, the number of available channels for a cell changes, and this number is affected by channel assignment in other cells. To theoretically and exactly analyze the teletraffic characteristics of such systems is difficult in general. Hence, the teletraffic characteristics are often evaluated by computer simulation.

Another way of evaluating the teletraffic characteristics of cellular systems using DCA is to use approximation techniques. Various kinds of approximation techniques have been proposed [2]–[8]. In [7], [8], an approximate technique using Clique Packing approximation has been proposed. Clique Packing approximation, which is based on the concept of Clique Packing [6], is one of the approximations. Clique Packing cannot accept more calls than the number of channels in a clique. A clique is a set of cells that are interference cells of each other. However, the practical DCA without full optimization ability cannot accept the same number of calls as channels in a clique. In [7], [8], it is shown that DCA algorithm with n_d channels has the similar teletraffic characteristics to Clique Packing with βn_d channels, where $0 < \beta \leq 1$. It is also shown that each DCA algorithm has its own value of β. We can obtain the blocking probability of Clique Packing an approximate formula [7], [8]. By using β in this approximation formula, the teletraffic characteristic of DCA can be analyzed. However, in [7], [8], Clique Packing approximation is given by assuming that terminals do not move. To apply Clique Packing approximation to actual system design, we should consider the effect of terminals' mobility on Clique Packing approximation. Also, approximate and theoretical analysis of teletraffic characteristics of DCA often assumes that terminals do not move though teletraffic characteristics of FCA are theoretically analyzed in some articles [9]–[15] etc.

This paper considers approximation techniques for analysis of teletraffic characteristics of DCA considering the mobility of terminals as these points as background. In this paper, we propose two approximation techniques to analyze the teletraffic characteristics of DCA considering the mobility of terminals. One technique is based on Clique Packing approximation, and we show that this approximation technique is effective to estimate the blocking probability and the forced termination probability of Clique Packing. Another is the approximation technique considering the property of the carried traffic of the system using DCA. In the second technique, we utilize the property that the velocity of terminals does not affect the carried traffic shown in this paper. In Sect. 2, models and assumptions used in this paper are described. Section 3 gives an approximation tech-

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[†]The author is with the Graduate School of Science and Technology, Niigata University, Niigata-shi, 950-2181 Japan.

[††]The authors are with the Department of Information Engineering, Niigata University, Niigata-shi, 950-2181 Japan.

a) E-mail: karasawa@ie.niigata-u.ac.jp

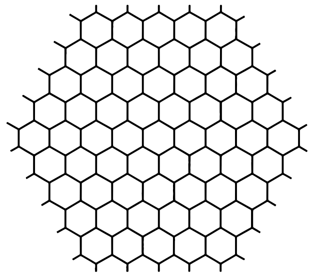


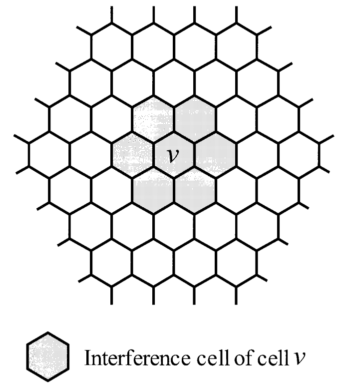
Fig. 1 2 dimensional service area.

nique to analyze the blocking probability and the forced termination probability of Clique Packing considering mobility of terminals. Then, we discuss whether the Clique Packing approximation is applicable to analysis of the teletraffic characteristics of DCA when it is assumed that terminals move. Section 4 gives another technique only to evaluate the carried traffic in cellular systems using DCA considering the mobility. Finally, conclusions are noted in Sect. 5.

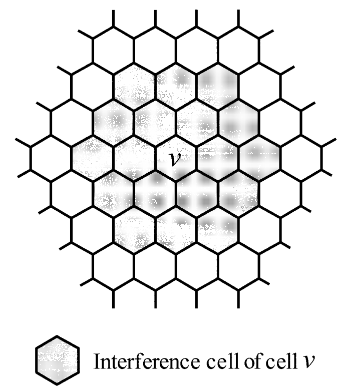
2. Models and Assumptions

This section gives models and assumptions used in this paper. The objective of this research is to theoretically analyze teletraffic characteristics of DCA. To simplify the analysis, we consider a service area as represented in Fig. 1. This service area consists of regular hexagonal cells. The radius of a cell is denoted by L. The system employs FDMA and a narrow frequency band is used as a channel and is reused in the service area. Let V be the set of all cells in the service area. If a channel is used in a cell, this channel cannot be used in some other cells because of interference. These cells are called the interference cells of the cell. If the interference cells of a given cell consist of all cells closer than p cells away from it, this system is called the p-belt buffering system. For example, we show the interference cells in Fig. 2. Suppose that cell v uses channel A. We cannot assign channel A to interference cells of cell v.

In the following, we define cliques. A clique is a set of cells that are interference cells of each other. Let $C(v)$ be the set of all cliques which include cell v. If c is a clique, $|c|$ denotes the number of cells included in c. If a clique is not included in any other cliques, this clique is called a maximal clique. If a maximal clique has the largest number of cells, this maximal clique is called a maximum clique. From the definition of the clique, it is obvious that a channel cannot be simultaneously assigned to cells included in a clique. Some cliques in the 2-belt buffering systems are shown in Fig. 3. Let $C_M(v)$ be the set of all maximum cliques which include cell v. Let $C'_M(v)$ be the set of all maximal cliques which include cell v. Examples of $C_M(v)$ are shown in Fig. 4. In Fig. 4 (a), there are 6 maximum cliques including cell v. In Fig. 4 (b), there are 7 maximum cliques including cell v. Other assumptions are as follows: The system is a loss system. The system is in a steady state. The call-arrival rate in each cell forms a Poisson process with the mean value λ_0. The time during which a call is active is an exponential random variable with the mean value h_0. Traffic intensity of each cell is $\lambda_0 h_0$. The number of cells in the service area is denoted by n_z. The number of channels in the system is denoted by n_d. If a call holding a channel enters the adjacent cell, this call requires a new channel in the adjacent cell. In this paper, such a requirement is called a hand-off call. Channel assignment methods do not



(a) 1-belt buffering systems



(b) 2-belt buffering systems

Fig. 2 Interference cells of cell v.

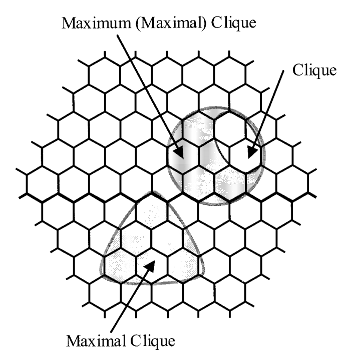
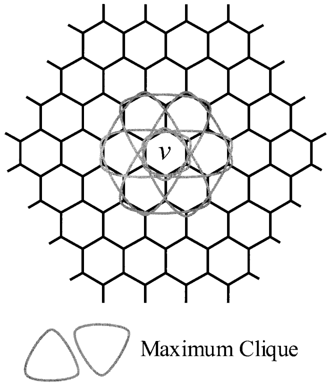
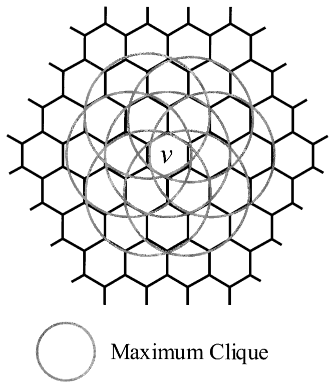


Fig. 3 Some cliques in the 2-belt buffering systems.



(a) $C_M(v)$ in the 1-belt buffering systems



(b) $C_M(v)$ in the 2-belt buffering systems

Fig. 4 Maximum cliques.

distinguish between hand-off calls and new calls. This means no priority for hand-off calls is assumed. This paper assumes that arrival of hand-off calls also forms a Poisson distribution with mean value λ. It is assumed that the channel occupancy time, during which a call holds a channel in a cell, is measurable in cell. The mean channel occupancy time of new calls is denoted by h_v. The mean channel occupancy time of hand-off calls is denoted by h_u. Let us define the mobility model by the following assumptions [11].

1. A new call moves straightforward in a period that has a truncated exponential distribution with mean value of 25 seconds. The direction to which the new call moves is decided randomly.
2. The velocity forms a truncated distribution that is combined Distribution 1 and Distribution 2, where the ratio of 3:1. Distribution 1 is a normal distribution with mean value of 25 km/h and standard deviation of 15 km/h. Distribution 2 is a normal distribution with mean value of 42 km/h and standard deviation of 8 km/h.
3. The direction has a truncated distribution that is combined Distribution 3 and Distribution 4, where the ratio of 1:2. Distribution 3 is a normal distribution with mean value of 82 degrees and standard deviation of 10 degrees. Distribution 4 is an exponential distribution with mean value of 10 degrees.

3. Mobility and Teletraffic Characteristics of Clique Packing

3.1 Clique Packing

Clique Packing is defined as an algorithm which cannot accept more calls than n_d in a clique. When a call arrives at cell v, Clique Packing works as follows:

Step 1: Count the number of calls except the arriving call in each clique of $C(v)$.
Step 2: Reject the call if some cliques already have the same number of calls as n_d, respectively. Accept the call in other cases.

Consider clique c_i which is not a maximal clique and is included in $C(v)$. From the definition of a maximal clique, c_i must be included in a maximal clique of $C'_M(v)$. When there exist n_d calls in c_i, there also exist n_d calls in this maximal clique. Therefore, in step1, we should consider only $C'_M(v)$. In [7], [8], it is shown that influence of the maximal cliques which are not maximum cliques on the teletraffic characteristics is negligibly small. Consequently, when a call arrives at cell v, channel assignment operation of Clique Packing can be simplified as follows:

Step 1: Count the number of calls except the arriving call in each of the maximum clique of $C_M(v)$.
Step 2: Reject the call if some maximum cliques already have the same number of calls as n_d, respectively. Accept the call in other cases.

An approximate formula for calculating the blocking probability of Clique Packing has been proposed [7], [8]. This formula is derived by assuming the following: It is assumed that the service area consists of regular hexagonal cells and traffic intensity of each cell is the same. p-belt buffering systems are assumed and it is also assumed that each cell has the same number of interference cells. This assumption means that we can neglect the edge effect. Furthermore, it is assumed that terminals never move. The approximate formula can be computed by using the Erlang B formula and some coefficients. It has been confirmed that the numerical results of the approximate formula agree with the computer simulation results. Furthermore, in [7], [8], it is shown that DCA with n_d channels has the similar characteristics to Clique Packing with βn_d channels, where $0 < \beta \leq 1$. It is also shown that each DCA algorithm has its own value of β in a system. The procedure for finding β is the following; First, we obtain blocking probabilities of a practical DCA as a function of the traffic intensity in each cell, which is denoted by a, by computer simulation. The blocking probability is denoted by $B(a)$. Replace n_d in approximate formula for calculating blocking probability of Clique Packing with βn_d assuming that βn_d is a positive integer. Denoted that $B_M(a, \beta n_d)$ is the blocking probability of Clique Packing with βn_d channels at offered traffic a. Calculate $\sum_a |B(a) - B_M(a, \beta n_d)|$ for $\beta n_d = 1, \ldots, n_d$. Then, we round n_f to the nearest integer, and find βn_d which makes $\sum_a |B(a) - B_M(a, \beta n_d)|$ the smallest. Finally, we obtain β of the practical DCA. From these characteristics, if it is possible to analyze the teletraffic characteristics of Clique Packing with βn_d channels, the results of analysis can be considered as the teletraffic characteristics of the DCA algorithm having n_d channels. It is assumed that terminals never move as mentioned above. In the following, we consider Clique Packing approximation in the case that hand-off occurs and terminals move in the service area.

3.2 Analysis

The blocking probability is the probability that a new call is blocked. The forced termination probability is the probability that a hand-off call is blocked. In this paper, B_M denotes the blocking probability of Clique Packing. B_H denotes the forced termination probability of Clique Packing.

At first, we consider B_M. Consider a new call originated in cell v. As described above, we consider only maximum cliques including cell v. Then, Clique Packing rejects the new call only if some of the maximum cliques of $C_M(v)$ already have n_d calls excluding the new call. Figure 5 shows an example of a new call which arrives at cell v in the 2-belt buffering system, where $n_d = 3$. In this example, c_1, c_3, c_4, c_5, c_6 and c_7 hold less than n_d calls. However, the new call is blocked because c_2 already holds n_d calls excluding the new call. For calculating the blocking probability of Clique Packing, we define the event E_i. The event E_i is the event that $c_i \in C_M(v)$ has n_d calls except the new call when a new call arrives at cell v. The new call is blocked if some of the events $E_1, E_2, \cdots, E_{n_v}$ occur, where $n_v = |C_M(v)|$. Then, B_M is expressed as follows [7], [8]:

$$B_M = P\left(\bigcup_{i=1}^{n_v} E_i\right), \tag{1}$$

where $P(E_i)$ denotes the probability that E_i will happen.

Next, we consider the forced termination probability of Clique Packing. Consider an active call that is served by the base station in cell v. Suppose that this active call leaves cell v and enters cell u, which is adjacent to cell v. This hand-off call requests to be connected to base station in cell u. The event F_j is the event that $c_j \in C_M(u)$ has n_d calls except the hand-off call. In this hand-off operation, Clique Packing must consider $c_j \in C_M(u)$ and count the number of calls in each maximum clique of $C_M(u)$ except the hand-off call. Then, Clique Packing rejects this hand-off call only if some of maximum cliques of $C_M(u)$ already have n_d calls, respectively. The hand-off call is blocked in cell u if some of the events $F_1, F_2, \cdots, F_{n_u}$ occur, where $n_u = |C_M(u)|$. Figure 6 shows an example of the hand-off call that leaves cell v and enters cell u in the 2-belt buffering system. If n_d is 3 in this example, the hand-off call is blocked because the number of calls in c_2 is equal to n_d except the hand-off call.

Note that every maximum clique in $C_M(v)$ has less than n_d calls in the hand-off operation. Therefore, it is considered that the forced termination probability is the probability that some of the maximum cliques in $C_M(u)$ has n_d calls excluding the hand-off call given that every clique in $C_M(v)$ has less then n_d calls. Then, B_H is expressed as follows:

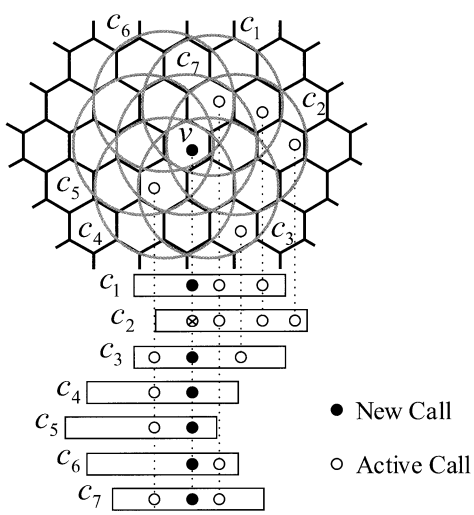


Fig. 5 An example of a new call which arrives at cell v.

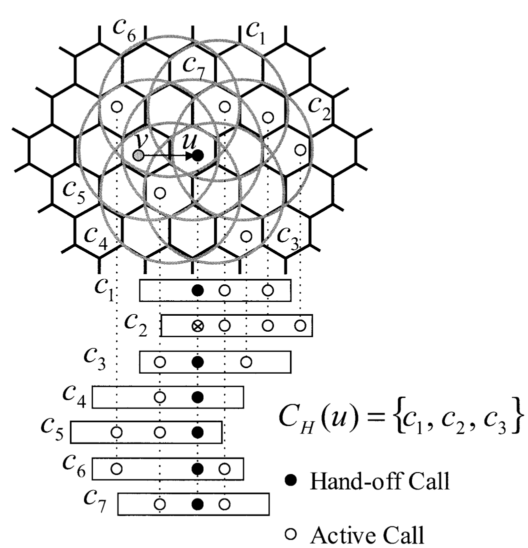


Fig. 6 An examples of the hand-off call which leaves cell v and enters cell u.

$$B_H = P\left(\bigcup_{j=1}^{n_u} F_j \,\middle|\, \overline{\bigcup_{i=1}^{n_v} E_i}\right), \tag{2}$$

where $\overline{A}$ is the complementary event of the event A. $\overline{\bigcup_{i=1}^{n_v} E_i}$ is the event that no cliques of $C_M(v)$ have n_d calls. $\bigcup_{j=1}^{n_u} F_j$ is the event that some cliques of $C_M(u)$ have n_d calls. $C_M(u)$ and $C_M(v)$ have an intersection. None of maximum cliques in this intersection have n_d calls excluding the hand-off call in the hand-off operation because this intersection is included in $C_M(u)$. Define that $C_H(u) = C_M(u) - C_M(v)$ and $n_h = |C_H(u)|$. Define that the event G_k is the event that $c_k \in C_H(u)$ has n_d calls except a hand-off call. Then, we can obtain B_H as follows:

$$B_H = P\left(\bigcup_{k=1}^{n_h} G_k \,\middle|\, \overline{\bigcup_{i=1}^{n_v} E_i}\right). \tag{3}$$

$C_H(u)$ and $C_M(v)$ have no intersection of maximum cliques. In this paper, for simplicity, we consider the event G_k and the event E_i are independent. Then, Eq. (3) is expressed as follows:

$$B_H = P\left(\bigcup_{k=1}^{n_h} G_k\right). \tag{4}$$

Let us consider Eqs. (1) and (4). As mentioned above, we define B_M represented in Eq. (1) as the probability that some of events E_i occur at the new call origination. In this paper, we assume that B_M in the system considering no hand-off operations where offered traffic is a_n is equivalent to B_M in the system considering the mobility where offered traffic is a. In other words, we consider offered traffic considering the influence of the mobility. Similarly, we assume that B_H in the system considering no hand-off operations where offered traffic is a_h is equivalent to B_H in the system considering the mobility where offered traffic is a. From these assumptions, B_M and B_H can approximately be derived as discussed in [7], [8]. In [7], [8], a maximum clique is modeled by a full-availability system with n_d channels. For the 1-belt buffering systems and the 2-belt buffering systems, B_M and B_H can be represented as follows:

$$\begin{aligned}
&B_{M,1-belt}\\
&= 6E_{3n_{f1}}(3a_{n1}) - \{6E_{4n_{f1}}(4a_{n1})\\
&\quad + 9E_{5n_{f1}}(5a_{n1})\} + \{6E_{5n_{f1}}(5a_{n1})\\
&\quad + 12E_{6n_{f1}}(6a_{n1}) + 2E_{7n_{f1}}(7a_{n1})\}\\
&\quad - \{6E_{6n_{f1}}(6a_{n1}) + 9E_{7n_{f1}}(7a_{n1})\}\\
&\quad + 6E_{7n_{f1}}(7a_{n1}) - E_{7n_{f1}}(7a_{n1})\\
&= 6E_{3n_{f1}}(3a_{n1}) - 6E_{4n_{f1}}(4a_{n1})\\
&\quad - 3E_{5n_{f1}}(5a_{n1}) + 6E_{6n_{f1}}(6a_{n1})\\
&\quad - 2E_{7n_{f1}}(7a_{n1}),
\end{aligned} \tag{5}$$

$$\begin{aligned}
&B_{H,1-belt}\\
&= 4E_{3n_{f1}}(3a_{h1}) - \{3E_{4n_{f1}}(4a_{h1})\\
&\quad + 3E_{5n_{f1}}(5a_{h1})\} + \{2E_{5n_{f1}}(5a_{h1})\\
&\quad + 2E_{6n_{f1}}(6a_{h1})\} - E_{6n_{f1}}(6a_{h1})\\
&= 4E_{3n_{f1}}(3a_{h1}) - 3E_{4n_{f1}}(4a_{h1})\\
&\quad - E_{5n_{f1}}(5a_{h1}) + E_{6n_{f1}}(6a_{h1}),
\end{aligned} \tag{6}$$

$$\begin{aligned}
&B_{M,2-belt}\\
&= 7E_{7n_{f2}}(7a_{n2}) - \{12E_{10n_{f2}}(10a_{n2})\\
&\quad + 6E_{12n_{f2}}(12a_{n2}) + 3E_{13n_{f2}}(13a_{n2})\}\\
&\quad + \{6E_{12n_{f2}}(12a_{n2}) + 15E_{13n_{f2}}(13a_{n2})\\
&\quad + 12E_{15n_{f2}}(15a_{n2}) + 2E_{16n_{f2}}(16a_{n2})\}\\
&\quad - \{6E_{14n_{f2}}(14a_{n2}) + 12E_{15n_{f2}}(15a_{n2})\\
&\quad + 8E_{16n_{f2}}(16a_{n2}) + 9E_{17n_{f2}}(17a_{n2})\}\\
&\quad + \{6E_{16n_{f2}}(16a_{n2}) + 9E_{17n_{f2}}(17a_{n2})\\
&\quad + 6E_{18n_{f2}}(18a_{n2})\} - \{6E_{18n_{f2}}(18a_{n2})\\
&\quad + E_{19n_{f2}}(19a_{n2})\} + E_{19n_{f2}}(19a_{n2})\\
&= 7E_{7n_{f2}}(7a_{n2}) - 12E_{10n_{f2}}(10a_{n2})\\
&\quad + 12E_{13n_{f2}}(13a_{n2}) - 6E_{14n_{f2}}(14a_{n2}),
\end{aligned} \tag{7}$$

$$\begin{aligned}
&B_{H,2-belt}\\
&= 3E_{7n_{f2}}(7a_{h2}) - \{2E_{10n_{f2}}(10a_{h2})\\
&\quad + E_{12n_{f2}}(12a_{h2})\} + E_{13n_{f2}}(13a_{h2})\\
&= 3E_{7n_{f2}}(7a_{h2}) - 2E_{10n_{f2}}(10a_{h2})\\
&\quad - E_{12n_{f2}}(12a_{h2}) + E_{13n_{f2}}(13a_{h2}),
\end{aligned} \tag{8}$$

where $n_{f1} = n_d/|c_i| = n_d/3$ and $n_{f2} = n_d/|c_i| = n_d/7$, c_i is a maximum clique. $E_s(a)$ is the Erlang B formula as follows:

$$E_S(a) = \frac{\dfrac{a^S}{S!}}{\sum_{i=0}^{S} \dfrac{a^i}{i!}}. \tag{9}$$

a_{n1} and a_{n2} are the offered traffic in a cell at the new call originations in the 1-belt buffering systems and in the 2-belt buffering systems, respectively. a_{h1} and a_{h2} are the offered traffic in a cell at the hand-off operations in the 1-belt buffering systems and in the 2-belt buffering systems, respectively. If a_n and a_h are obtained, we can calculate B_M and B_H. At first, we consider a_n. a_n is less than $\lambda_0 h_0$ because some traffic is lost at the hand-off operations in the system. Then, approximately, we assume that a_n is equal to the amount of offered traffic of the new calls and that of the hand-off calls. So, a_n is obtained as follows:

$$a_n = \lambda_0 h_v + \lambda h_u. \tag{10}$$

Next, we consider a_h. a_h is less than a_n because some traffic is lost at the new call originations in the system. Assuming that lost traffic is equal to $\lambda_0 h_v B_M$ approximately, a_h is obtained as follows:

$$a_h = \lambda_0 h_v (1 - B_M) + \lambda h_u. \quad (11)$$

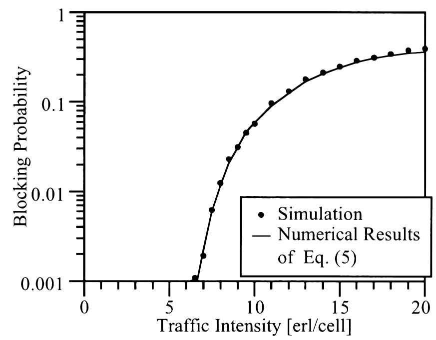
As assumed above, λ, h_v and h_u are measurable. Hence, we can utilize these parameters to compute B_M and B_H.

Figure 7 shows numerical results and computer simulation results. To obtain the numerical results, h_v, h_u and λ are obtained by computer simulation. It is also assumed that L is equal to 1 km and h_0 is equal to 1.5 minutes. $n_z = 169$. To ignore the influence of bounds of the service area on the teletraffic characteristics, we consider only the teletraffic characteristics in the central 91 cells [7], [8]. The results show that the numerical results of approximate formula agree with computer simulation results even though the formula is obtained by using some approximations.

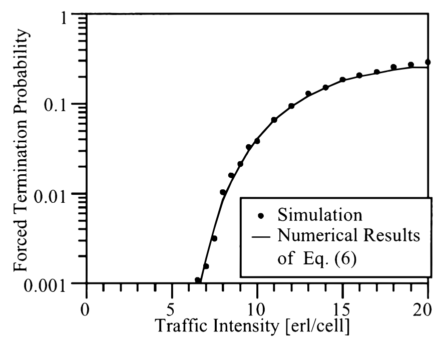
Furthermore, we try to estimate the blocking probability and the forced termination probability of practical DCA by using our proposed approximate formula and Clique Packing approximation [7], [8]. In this paper, as a practical DCA, we consider First-available method [2], [7], [8]. Figure 8 shows the numerical results and computer simulation results. The numerical results are calculated by using Eqs. (5)–(8) and β [7], [8]. In [7], [8], β in the 1-belt buffering systems with 36 channels is 0.83, and β in the 2-belt buffering systems with 84 channels is 0.75. The results show that DCA with n_d channels has the similar characteristics to Clique Packing with βn_d channels even if the mobility of terminals is introduced to analysis.

4. Characteristics of Carried Traffic in Cellular Systems Using DCA

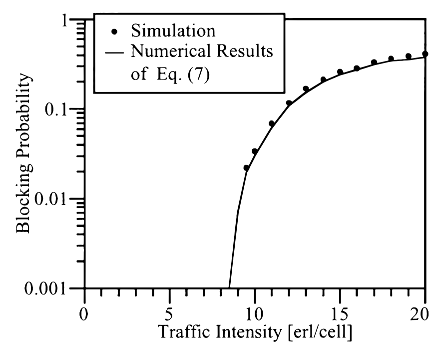
In the preceding section, we have discussed the blocking probability and the forced termination probability in cellular systems using DCA by using Clique Packing approximation. In this discussion, some assumptions and approximations are introduced for simplicity. In this section, we discuss carried traffic in cellular systems using DCA. As the mobility model in this section, we consider the constant velocity of terminals. Other assumptions of the mobility are represented in Sect. 2. Figure 9 shows carried traffic of the system using Clique Packing. These results are obtained by computer simulation. Figure 9(a) shows carried traffic in the 1-belt buffering systems where the number of channels is 36. Figure 9(b) shows carried traffic in the 2-belt buffering systems where the number of channels is 84. Furthermore, we evaluate carried traffic in cellular systems using First-Available method. Figure 10(a) shows carried traffic in the 1-belt buffering systems where the number of channels is 36. Figure 10(b) shows carried



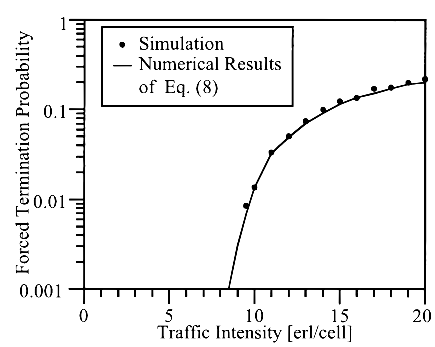
(a) Blocking probability in the 1-belt buffering systems with 36 channels



(b) Forced termination probability in the 1-belt buffering systems with 36 channels

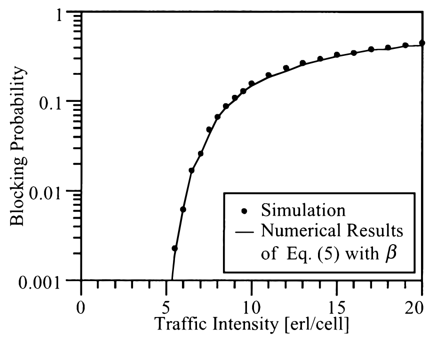


(c) Blocking probability in the 2-belt buffering systems with 84 channels

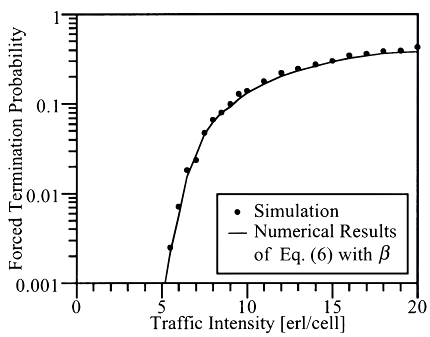


(d) Forced termination probability in the 2-belt buffering systems with 84 channels

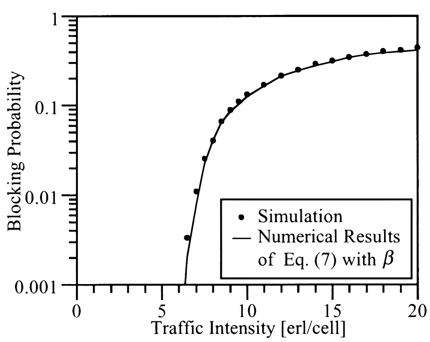
Fig. 7 Blocking probabilities and forced termination probabilities of Clique Packing.



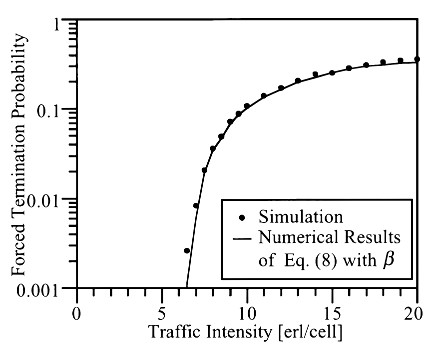
(a) Blocking probability in the 1-belt buffering systems with 36 channels



(b) Forced termination probability in the 1-belt buffering systems with 36 channels

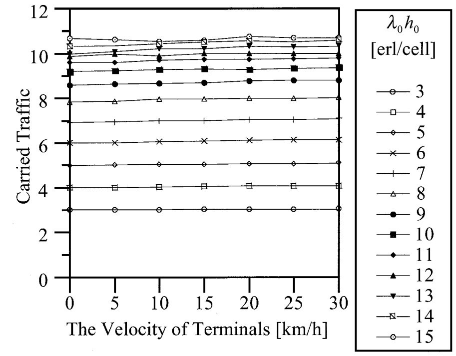


(c) Blocking probability in the 2-belt buffering systems with 84 channels

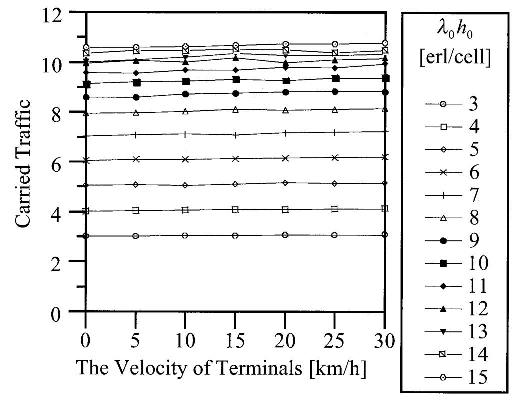


(d) Forced termination probability in the 2-belt buffering systems with 84 channels

Fig. 8 Blocking probabilities and forced termination probabilities of First-Available method.



(a) 1-belt buffering systems with 36 channels

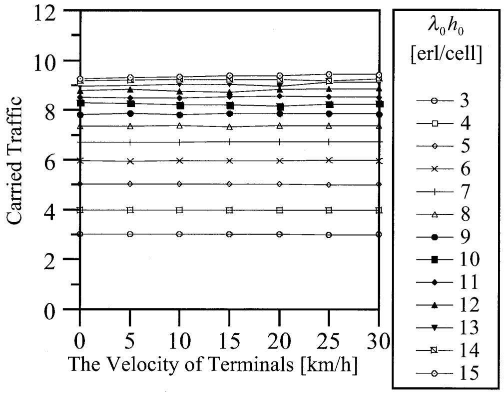


(b) 2-belt buffering systems with 84 channels

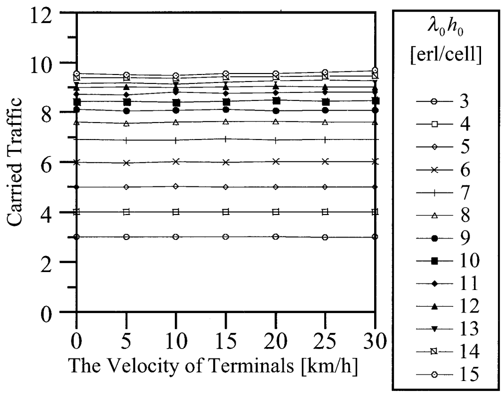
Fig. 9 Relation between the velocity of terminals and carried traffic in cellular systems using Clique Packing.

traffic in the 2-belt buffering systems where the number of channels is 84.

From these results, it is considered that influence of mobility on carried traffic is small in cellular systems using DCA. Let us consider this property. When the velocity of terminals is equal to 0 km/h, carried traffic in the system is equal to $\lambda_0 h_0(1 - B_M)$ because the system does not have lost traffic at the hand-off operations. As the mean velocity of terminals becomes larger, λ increases and h_v decreases because each call reaches the cell boundary quickly. On the other hand, as h_v decreases, the offered traffic decreases. As λ increases, the offered traffic increases. From the results, it is considered that the offered traffic does not change because λ increases and h_v decreases. In this paper, we confirm this property in the range of the velocity from 0 to 30 km/h. The formula, proposed in [7], computes the blocking probability of Clique Packing if calls do not move. Using this formula, we can compute carried traffic when the velocity of terminals is equal to 0 km/h. Then, we can approximately compute carried traffic in the system using Clique Packing in the range from 0 to 30 km/h. Furthermore, we can estimate carried traffic in the system using practical DCA by using β and the formula for calculating the blocking probability of



(a) 1-belt buffering systems with 36 channels



(b) 2-belt buffering systems with 84 channels

Fig. 10 Relation between the velocity of terminals and carried traffic in cellular systems using First-Available method.

Clique Packing. The technique discussed in this section computes only carried traffic; however, it is considered that carried traffic is an important parameter when we design cellular systems using DCA. The technique is very simple. Hence, this technique is valuable for design of cellular systems using DCA.

5. Conclusions

In this paper, we have proposed two approximation techniques for analysis of the teletraffic characteristics of DCA methods considering the mobility of terminals. The first method gives the blocking probability and the forced termination probability by using the Clique Packing approximation. For this method, we have approximately derived equations to compute the blocking probability and the forced termination probability of Clique Packing assuming terminals move in the service area. The second one gives carried traffic by using the formula which has already been proposed. This method is based on the property that influence of mobility on carried traffic is very small. This property is shown by computer simulation results. These results are useful to estimate teletraffic characteristics of cellular systems. This paper has introduced a lot of assumptions and estimations for simplicity. It is our future problem to analyze DCA in more practical models. For example, to consider irregular cell structure is considered as one of the future problems.

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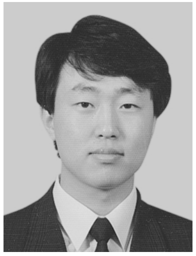

Heun-Soo Lee received the B.E. degree from Ajou University, Suwon Korea, in 1990, and the M.E. degree from Niigata University in 1994. He is now a doctoral student at Niigata University. His research interests include teletraffic analysis, computer networks and pedestrian tracking using a GPS. He is a student member of KICS.

Naoyuki Karasawa received the B.E. and the M.E. degrees from Niigata University in 1996 and 1998, respectively. From 1998 to 1999, he worked at NEC Corporation. He is now a research associate at the Department of Information Engineering, Niigata University. He received the Excellent Paper Award of IEICE in 1997. His research interests include performance evaluation of mobile communication networks, TCP/IP networks and wireless multi-hop networks.

Keisuke Nakano received the Ph.D. degree from Niigata University in 1994. He is currently an Associate Professor of Department of Information Engineering at Niigata University, Japan. He received the Best Paper Award of IEEE ICNNSP'95 in 1996 and the Excellent Paper Award of IEICE in 1997. He was a visiting scholar at University of Illinois at Urbana-Champaign in 1999. His research interests include network systems, such as computer networks and mobile networks.

Masakazu Sengoku was born in Nagano Pref., Japan, on October 18, 1944. He received the B.E. degree in electrical engineering from Niigata University, Niigata Japan, in 1967, and the M.E. and Dr.Eng. degrees in electronic engineering from Hokkaido University in 1969 and 1972, respectively. In 1972, he joined the staff at the Department of Electronic Engineering, Hokkaido University as a Research Associate. In 1978, he was an Associate Professor at the Department Information Engineering, Niigata University, where he is presently a Professor. His research interests include network theory, graph theory, transmission of information and mobile communications. He received the 1992, 1996, 1997 and 1998 Excellent Paper Awards from IEICE and IEEE ICNNSP Best Paper Award in 1996. He was the chairperson of the IEICE Technical Group on Circuits and Systems in 1995. He is a member of Editorial Board, ACM, URSI, Wireless Networks, Baltzer Science Pub. He is the Vice-President of Communication Society, IEICE, in 2000. He is also the chairperson of IEICE International Technical Group on System and Signal Processing and the vice-chairperson of IEICE Technical Group on Multidimensional Mobile Communications. Dr. Sengoku is a Fellow member of IEEE, a member of the Information Processing Society of Japan.