MINIMISING RESERVED CHANNELS TO SATISFY HANDOVER REQUESTS FOR VOICE CALLS IN MOBILE COMMUNICATION SYSTEMS USING HANDOVER CHANNEL RELAYING STRATEGY

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Abstract: In this paper, the channel reservation in wireless communications systems will be reviewed**.** Normally, the systems have to save a certain number of channels to deal with the handover requests that resulting from the mobility of users. The great concern is how much bandwidth needed to reserved to satisfy not only handoff rates but also channel utilization. In this research, we try to minimize the number of reserved channels. It is proposed that the system would be reserved only one channel to overcome the concern. The motivation for this reservation scheme is the capability of Handover Channel Relaying Strategy (HCRS) to improve the dropping rate as well as the best effort of networks resource reservation. The simulation results show that HCRS with One Reserved Channel (HCRS-ORC) presented in this reasearch can serve more than 99.99% of handover calls. This is the significant contribution of the paper.

Keywords: channel reservation, handover, channel relaying strategy.

I. INTRODUCTION

In the mobile wireless systems, the network coverage generally has been devided into smaller areas that are called cells. Cell refers to a radio base staion that covers a certain geographic region. This is resulted from the limitation of transmitted power and the constraint of antenna high. Handover represents a process of switching traffic channels from home cell to the target guest cell during the conversation of mobile user. Handover is the key function of the mobile communication networks that serve the calls of freely moving users [1]. In the customer's points of view, dropping the handoff call is more annoying than blocking a new originated call. Consequently, there are a number of channels that should be reserved for handover, or at least the handover request should have a priority over a new call request in the network [1-13]. The reservation is the preferred scheme that is applied widely in practical wireless cellular networks to satisfy the

dropping probability. However, it is difficult to determine how much capacity of a network should be reserved for handover requests. The computation of the optimal reserved channels is really the challenge for researchers.

The reserved channels could be fixed or dynamic [4-6]. Misra in [4] and Lim in [5] proposed the reservation strategy with a fixed number of guard channels. The call dropping propability has been improved, but the channel utilization has not mentioned in these research [3-5]. Dynamic channel reservation strategy can reach the goals of handover and bandwidth utilization [6]. However, the results in paper [6] shown that there is at least 3% of capacity should be reserved for best handoff effect.

To gain the resource utilization, the authors in [7-8] apply the strategy of combination of channel reservation and channel borrowing. Moreover, when the handoff rate is high enough, the queue for on-going calls is set for reducing the call dropping propability (CDP) [7]. However, the CDP in [7] still stands at the values more than 2.5%. This is really the drawback of the paper.

For best channel utilization, the authors in [13] have proposed the HCRS without reservation. In this paper, it is assumed that all traffic channels allocated to cell will be assigned to originated new calls. Then, the HCRS will be applied to serve the handover calls. Although operation without reserved channels, this strategy has pointed out the considerable capability in serving the handover calls with the dropping propability less than 1% in the case of there are 40 traffic channels assigned to each cell. However, this propability will be increased to 5% when there are 20 traffic channels provided to the cells. This leads to the need of channel reservation that presented in this research. The results abtained in this paper shown that the dropping rates are less than 0.01% and 0.1% when the numbers of channels in a cell are 40 and 20 respectively. Moreover, the channel utilization in the condition of heavy traffic load seems to be reached when there is only one channel need to be reserved.

The rest of paper is organized as follows. Section II discusses channel reservation strategy and handover propability in cellular wireless networks. Section III analyses the Handover Channel Relaying Strategy with One Reserved Channel (HCRS-ORC). The simulations of HCRS-ORC will be presented in Section IV. Finally, Section V will conclude the paper.

II. CHANNEL RESERVATION AND HANDOVER PROPABILITY

A. Channel Reservation

Assume that the Fixed Channel Assignment (FCA) strategy is applied to the wireless communication networks. Then, each cell will be assigned N_C channels as [2, 4, 6, 7, 9, 12]:

$$N_C = \frac{BW}{N} \qquad (1)$$

where BW is the total bandwidth (in channels) of the networks, N is the cluster size or reuse factor, then N_C is also called as capacity of the cell.

Normally, in the channel reservation strategy, the threshold t_c will be used to devide N_C into 2 groups as [4, 6, 7, 9, 12]:

$$\begin{cases} N_n = (1 - t_c) \cdot N_C \\ N_r = t_c \cdot N_C \end{cases} \qquad (2)$$

where N_n can serve either new or handoff calls; and N_r is the reserved capacity and is only to use for handover calls. In [12], the author proposed that N_n and N_r will will be used separately for new and handoff calls respectively. The capacity of reserve strongly affects the dropping probability. This probability, however, is determined via the handover rate of a cell and the conversation time of users. Technically, the handover rate is applied for calculations of dropping rate and the fraction of reserved channels. The handover rate is computed from the new call arrival rate as follows [4, 12]:

$$L_h = \frac{(1 - P_{bn})P_h}{1 - (1 - P_{dh})P_h} L_n \qquad (3)$$

where P_{bn} and P_{dh} are the probabilities of blocking new calls and dropping handover calls respectively; P_h is the probability that an on-going user in one cell will hand over to another cell during the conversation; and L_n and L_h are new call and handover call arrival rates. The parameter P_h is also known as the handover probability and will be determided in the following section.

B. Handover Propability

The handover procedure is one of the basic operations of wireless networks due to the mobility of users. In mobile cellular telephone systems, handover occurs when the on-going call moves from the coverage of the current cell serving him to the new service area. Consequently, the handoff rate is strongly affected by the cell size. Depending on the cell radius and other parameters related to the user's mobility, the probability of handover P_h is determined [12].

In practical deploy networks, the coverage radius of a cell is the standard parameter and this parameter could be varied depending on the geographic sizes and user density in different areas of the network. However, the cell size chosen is based on the corresponding channel assignment and frequency reuse models used. Then, with the certain sample of frequency reuse (or certain cluster size), the radius of a cell is fixed. In this case, the probability of handover P_h could be calculated via fours variables of user's mobility such as the initial location of the user, velocity and direction of motion, and the conversation time of the user during the movement as shown in Figure 1 [12].
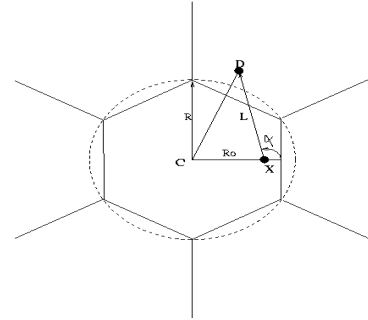

Figure 1. Calculating P_h

Assume that the mobile stations (MS) have been distributed randomly and uniformly in each cell, then the probability of handover P_h of MS X that initially generates a new call in the certain cell can be determined as follows [12]:

- The location of X is determined by the distance from X to cell C. In Fig.1, this distance is denoted by CX = R_0 (= d), where R_0 is varied from 0 to R (R is the radius of the cell). The probability density function (pdf) of R_0 is $f(R_0)$:

$$f(R_0) = \begin{cases} \dfrac{1}{R}, & for \ \ 0 \le R_0 \le R \\ 0, & otherwise \end{cases} \qquad (4)$$

- After generating a call, X freely travels during its conversation. Assume that the velocity $\vec{V}$ is constant during movement, and V is uniformly distributed from 0 to V_{Max}. The upper bound of V_{Max} is dependent on the traffic condition in certain areas of networks. The pdf $f(V)$ of V is [2]:

$$f(V) = \begin{cases} \dfrac{1}{V_{Max}}, & for \ \ 0 \le V \le V_{Max} \\ 0, & otherwise \end{cases} \qquad (5)$$

- We could also assume that the direction of mobility is not changed until X terminates his call (either natural or forced termination). The direction is represented by α, where $\alpha = (\overrightarrow{CX}, \vec{V})$, or $\alpha = (\overrightarrow{CX}, \overrightarrow{XD})$ as shown in Figure 1. In general, α could be varied from 0 to 360°.

- Finally, the conversation time t of user X is a random variable and it is assumed to be negative exponentially distributed with the expected value $E[t]$. The probability density function $f(t)$ of t could be expressed as [2]:

$$f(t) = \begin{cases} 0, & for \ \ t < 0 \\ \mu \cdot e^{-\mu t}, & for \ \ t \geq 0 \end{cases} \quad (6)$$

where $\mu = \dfrac{1}{E[t]}$, or the expected value $E[t] = \dfrac{1}{\mu}$.

Hence, P_h is the propability that user X moves out of cell. In this case, the distance from cell C to the destination point D is larger than the radius of cell (in Fig.1, CD > R). Hence, the values of P_h with $R = 1500m$, $V_{Max} = 15m/s$ and $25m/s$, and $E[t] = [120 \ 150 \ 180]$ seconds are presented in Table 1.

Table 1. Probability of handover P_h in conventional network

V_{Max}	15m/s			25m/s		
E[t]	120	150	180	120	150	180
P_h	0.37	0.43	0.48	0.24	0.3	0.34

The results of P_h shown in this paper are comparable with the dropping propability in [2].

III. HANDOVER CHANNEL RELAYING STRATEGY WITH ONE RESERVED CHANNEL

A. Handover Channel Relaying Strategy (HCRS)

The basic operations of HCRS have been shown in Figure 2. Recall that the concepts of relay station (RS), hot and cold cells and related notations of HCRS have been analysed in [12-13]. In this paper, the principles of HCRS will be reviewed briefly as follows.

Assume that base station (BS) A and BS B in Figure 2 are the hot cells. User A_j is original generated a new call in cell A and is moving to cell B during the conversation.

When A_j crosses the border of cell A, the call still be served as long as A_j standing in the coverage of RS2. HCRS will be activated when A_j moves out of RS2 and releases the occupied channel A_j of cell A.
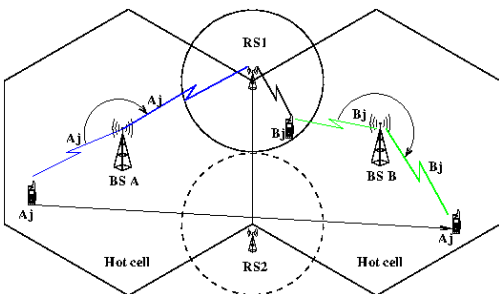

Figure 2. Handover Channel Relaying Strategy HCRS

To serve the call of MS A_j, cell B has to find the on-going MS B_j that originated new call in the cell and is standing in the service area of RS1. B_j is occupying a channel B_j of cell

B. Then, the channel swapping will be employed between A_j and B_j to serve the handoff call of MS A_j. This means that MS B_j will be switched to use a channel A_j in cell A via RS1 (MS B_j → RS1 → cell A), and channel B_j released by MS B_j in cell B now is assigned to MS A_j (MS A_j → cell B). The propability of handover of HCRS network is presented in Table 2 [12].

Table 2. Propability of handover P_h in HCRS network

V_{Max}	15m/s			25m/s		
E[t]	120	150	180	120	150	180
P_h	0.29	0.35	0.4	0.17	0.22	0.27

In [12-13], the author proposed the HCRS without reservation for best channel utilisation. This means that $N_r = 0$, and all N_C channels have been assigned to serve new calls. Moreover, the network is modelled as heavy congested with the traffic load is very high so that the channel released by certain call (either terminated in a cell or handed-over to neighbour cell) will be immediately occupied by another call if HCRS has not been activated. The state diagram of HCRS without reservation has been pointed in Figure 3. In the case of HCRS has not been employed and $N_r = 0$, the probability of dropping handover calls is:

$$P_{dh} = \dfrac{\dfrac{T_h^{N_r}}{N!}}{\displaystyle\sum_{k=0}^{N_r} \dfrac{T_h^k}{k!}} = 1 \quad (7)$$

where T_h is the handoff traffic load. Therefore, the propability of successful handover P_{sh} is:

$$P_{sh} = 1 - P_{dh} = 0 \quad (8)$$

When HCRS is applied, the P_{sh} has been significantly improved [13]. It is claimed that when the capacity of a cell is large enough ($N_C = 40$ channels), the CDP is reduced to 0.5%. The values of CDP will increase to 1.5% when $N_C = 30$, and jump to 5% when $N_C = 20$. The results of P_{sh} of HCRS without reserved channels presented in [13] have proved these statements.
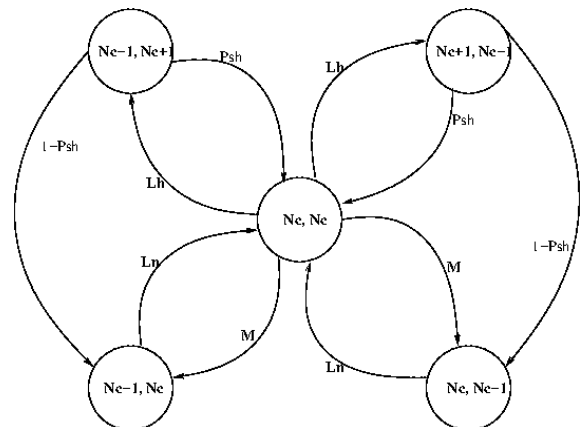

Figure 3. State diagram for HCRS without reservation

B. Handover Channel Relaying Strategy with One Reserved Channel (HCRS-ORC)

According to the condition that all N_C channels have been assigned to new calls, the P_{sh} of HCRS without reserved channels is depended on the propability of the on-going call standing in the coverage of a certain RS. Then, when the capacity of a cell is low ($N_C = 20$), the $P_{dh} = 0.05$ [13]. This means that there are 5% of handover calls will be dropped. This is hardly acceptable in practical networks. Then, it is necessary to reserve at least one channel to reduce the dropping propability. The diagram for HCRS-ORC is shown in Figure 4.
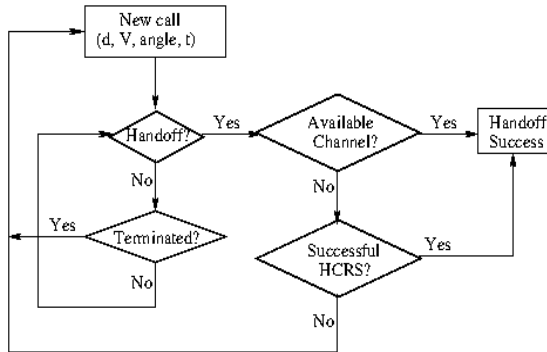

Figure 4. Agorithm for HCRS-ORC

Generally, after the on-going call has handed over successfully to the new cell, the call of this user could be treated as a new call in that cell in terms of channel assignment. Then, all of first handoff calls in all cell are mostly served. Afterward, the HCRS will be activated if there is not any available channel in a cell. In fact, there are just (N_C -1) channels assigned to new calls, then the new call arrival rate is decreased. This leads to the handoff rates also have been reduced. This seems that the call dropping rates will have been significantly improved.

IV. SIMULATIONS

The network model of 19 cells is shown in Figure 5. The parameters of the simulations are shown in Tabe 3. The results of propability of successful handover P_{sh} with average and high velocity are presented in Figure 6 and Figure 7. The propability of handover P_h is pointed in Figure 8.
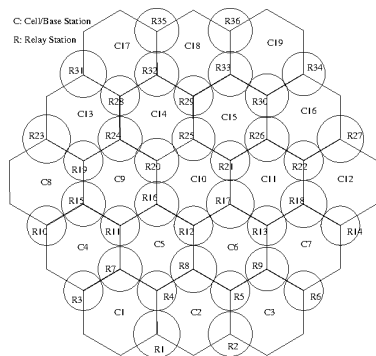

Figure 5. Network model for HCRS-ORC

Table 3. Simulation parameters

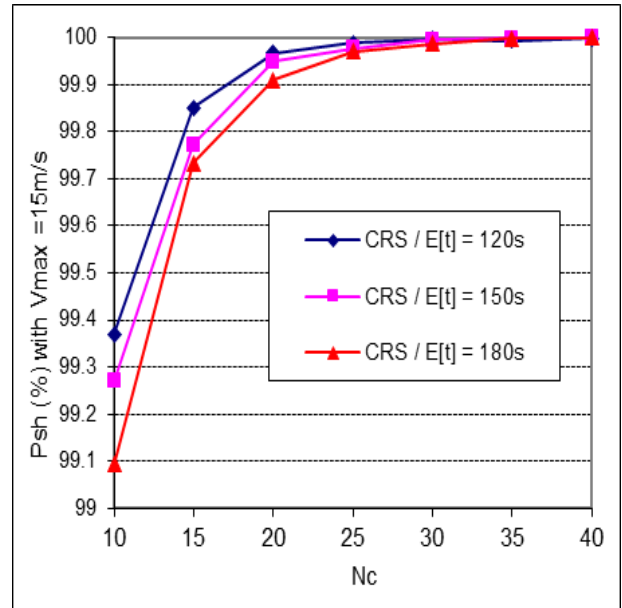| Notations	Values
R	1.500 m
N_C	[10:5:40]
V	[0 – 15] m/s and [0 – 25] m/s
t	[120:30:180] seconds

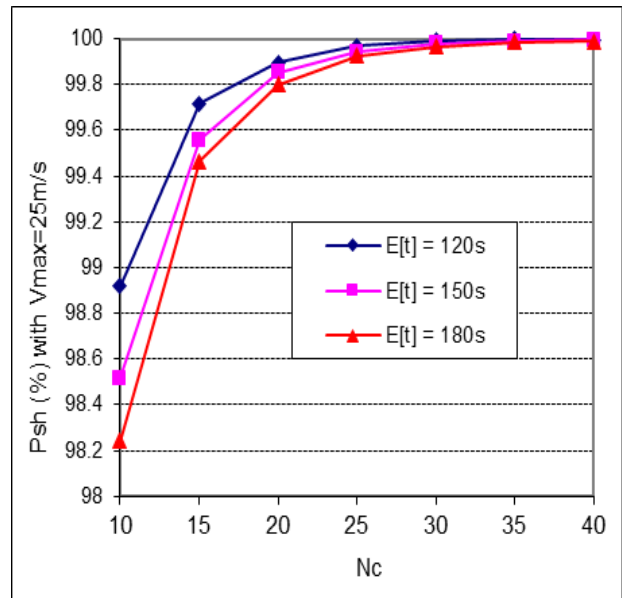*Figure 6. P_{sh} with everage velocity*

Figure 7. P_{sh} with high velocity

It can be seen from Figure 6 and Figure 7 that when $N_C = 20$, the dropping propability $P_{dh} = 0.1\%$ with $V_{Max} = 25$m/s; and $P_{dh} = 0.2\%$ with $V_{Max} = 15$m/s. Moreover, when the capacity of a cell is decreased to small value ($N_C = 10$), P_{dh} is also reduced to about 1% and 1.8% with $V_{Max} = 25$m/s; $V_{Max} = 15$m/s respectively.
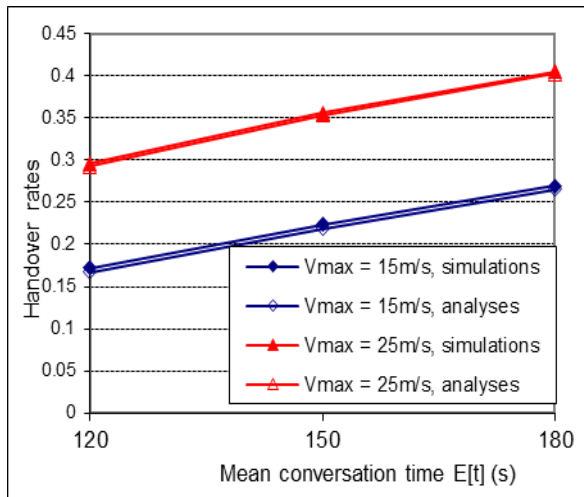
Figure 8. Propability of handover

The results in Figure 8 have also shown the match between the analyses and simulaltions in term of handover propability.

V. **CONCLUSIONS**

To summary, there are four main contributions presented in this paper. Firstly, the channel reservation strategies have been briefly reviewed. This provides the basic concepts for this research. Then, the simple calculation of propability of handover has been introduced. Althought simplicity in determination, the analytical results of handover shown in this paper could be compared with the results of other research. Moreover, the HCRS without reservation and its limitation has been quickly reviewed to motivate this research. Finally, the principles and simulations of HCRS-ORC have been pointed out to show the significant contribution presented in this paper, in which that the network just reserve only one channel to satisfy the handover requests of voice calls.

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TỐI THIỂU CÁC KÊNH DỰ TRỮ ĐỂ THỎA MÃN CÁC YÊU CẦU CHUYỂN GIAO CHO CÁC CUỘC GỌI THOẠI TRONG CÁC HỆ THỐNG THÔNG TIN DI ĐỘNG SỬ DỤNG KỸ THUẬT CHUYỂN TIẾP KÊNH

Tóm tắt: Trong bài báo này, việc dự trữ kênh trong các hệ thống truyền thông vô tuyến sẽ được đề cập. Thông thường, các hệ thống cần phải giữ lại một số kênh nhất định để cho các yêu cầu chuyển giao đến từ các thuê bao di động. Mối quan tâm lớn của việc này là cần phải dự trữ bao nhiêu tài nguyên để có thể thỏa mãn không chỉ các yêu cầu chuyển giao mà còn phải thỏa mãn được yêu cầu về tận dụng băng thông. Trong nghiên cứu này, chúng tôi cố gắng tối thiểu số lượng các kênh dự trữ. Một đề xuất được đưa ra là hệ thống sẽ chỉ cần dự trữ một kênh để giải quyết mối quan tâm trên.

Động lực cho phương thức dự trữ kênh này là khả năng của kỹ thuật chuyển tiếp kênh chuyển giao HCRS để cải thiện tỷ lệ rớt cuộc gọi cũng như hiệu quả tốt nhất của việc tận dụng tài nguyên mạng. Các kết quả mô phỏng chỉ ra rằng HCRS với một kênh dự trữ được trình bày trong nghiên cứu này có thể đáp ứng được hơn 99.99% các cuộc gọi chuyển giao. Đây là một đóng góp đáng kể của bài báo.

Từ khóa: dự trữ kênh, chuyển giao, kỹ thuật chuyển tiếp kênh.

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