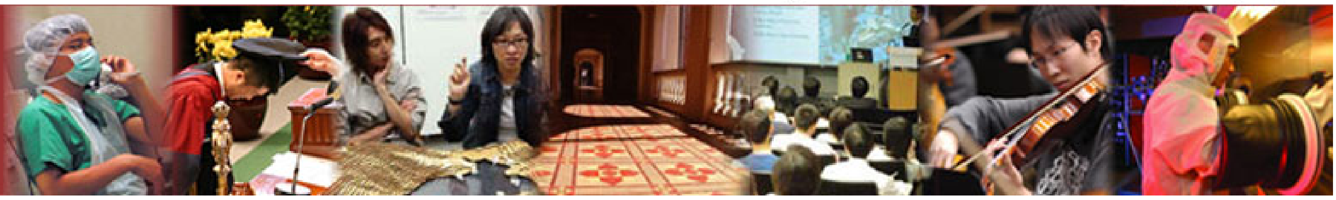

Performance analysis of dynamic channel assignment with queuing and guard channel combined scheme for handoff prioritisation

Zhi Hua Zheng and W.H. Lam

An analytical method to calculate the performance of dynamic channel assignment with queuing and guard channel combined scheme for handoff prioritisation is proposed. Closed form expressions of the call blocking and handoff failure probability are respectively evaluated. The analytical and simulation results show good agreement.

Introduction: As forced termination of an ongoing call is more serious than blocking a new call in cellular mobile systems, two handoff prioritisation schemes were proposed in the literature [1], the guard channel scheme (GC) and the queuing scheme (QH). The combined strategy of analytical results in fix channel assignment (FCA-GC-QH) and simulation results in dynamic channel assignment (DCA-GC-QH) were further evaluated in [2]. However, the theoretical analysis of DCA-GC-QH is seldom due to the complexity of the computation. In this Letter, an analytical method is investigated to calculate the performance of DCA-GC-QH. Analytical results are compared with simulation results with a difference of less than 7%.

Theoretical analysis for DCA-GC-QH: Consider a cellular system that has uniform traffic distribution with the following assumption. A total number of RxM channels is initially allocated to a cluster with the FCA scheme [2], where R is the cluster size and M is the number of channels in each cell. However, when there is no idle channel in a particular cell, other suitable channels in the neighbouring cells can be borrowed, subject to certain rules and the co-channel interference constraints (CCI) [4]. Both the new and handoff call arrivals follow a Poisson process with arrival rates λ_n and λ_h, respectively. The call holding time, mobile terminal mean dwell time and degradation time interval of a mobile terminal in the overlap area between cells are all assumed exponentially distributed with means $1/\mu$, $1/\eta$ and $1/\gamma$, respectively. Let P_b and P_h be the call blocking probability and the handoff failure probability in a cell, respectively. The handoff arrival rate λ_h in a cell is given by [1]

$$\lambda_h = \frac{\eta((1-P_b)}{\mu+\eta P_h}\lambda_n \tag{1}$$

For handoff priority, N number of M channels in a cell are reserved only for the handoff arrival call in the cell or its neighbouring cells. The channel allocation scheme begins with the $R(M-N)$ non-reserved channels allocated to both handoff and new call arrival calls in the cluster. While these channels are all occupied, new calls are blocked, and the handoff arrival calls are served with the RN reserved channels. Further, when there is no idle reserved channel, the handoff arrival calls can be queued for release channels with the first input first output (FIFO) discipline [2].

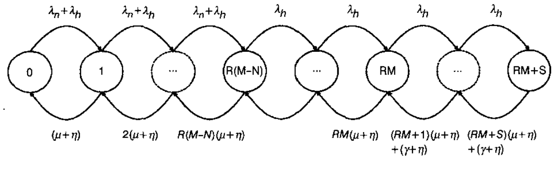

Fig. 1 *State diagram of M/M/M/T model for DCA-GC-QH scheme*

The channel allocation process in DCA-GC-QH can act as the $M/M/M/T$ system [2] with the state diagram shown in Fig. 1. Let i denote the number of the queued handoff arrival call ($0 \le i \le s$), Let j denote the total number of the occupied channels and the queued handoff arrival calls in the cluster ($0 \le j \le T$), where T is the maximum number of calls in the cell including both new arrival and handoff arrival calls; $T = RM + s$, s is the finite queue length for the handoff arrival calls. Define λ_{L_1} and λ_{L_2} as the call arrival rates in the cluster for $0 \le j \le R(M-N)$ and $R(M-N) < j \le RM + s$, respectively, where $\lambda_{L_1} = R(\lambda_n + \lambda_h)(1 - b(j))$ and $\lambda_{L_2} = R\lambda_h(1 - b(j))$.

The steady state probability P_j can be proposed as

$$\begin{aligned}
P_j &= \frac{\lambda_{L_1}^j}{j!(\mu+\eta)^j}P_0, \quad 0 \le j \le R(M-N) \\
P_j &= \frac{\lambda_{L_1}^{R(M-N)}\lambda_{L_2}^{j-R(M-N)}}{j!(\mu+\eta)^j}P_0, \quad R(M-N) < j \le RM \\
P_j &= \frac{\lambda_{L_1}^{R(M-N)}\lambda_{L_2}^{j-R(M-N)}}{(RM)!(\mu+\eta)^{RM}\prod_{i=0}^{j-RM}((RM+i)(\mu+\eta)+i(\gamma+\eta))}P_0, \\
&\qquad RM < j \le RM + s
\end{aligned} \tag{2}$$

where P_0 can be deduced from $\sum_{j=0}^{RM+S} P_j = 1$.

The notation $b(j)$ is the probability that the new arrival calls or handoff arrival calls may be blocked or queued even if there are still non-reservation channels available or reserved channels in the cluster. This is due to CCI arising from the use of the same channel in the neighbouring cells [4].

The probability $b(j)$ can be written as [3]

$$\begin{aligned}
b(j) &= (1 - [1-\omega_1]^g)^{M-N-\lfloor j/R \rfloor}, \quad 0 \le j \le R(M-N) \\
b(j) &= (1 - [1-\omega_2]^g)^{M-\lfloor j/R \rfloor}, \quad R(M-N) < j \le RM + s
\end{aligned} \tag{3}$$

where

$$\omega_1 = \frac{(1-P_b)D_1 + (1-P_h)D_2}{(g+1)(M-N)} \text{ and}$$
$$\omega_2 = \frac{P_h(1-P_b)D_2}{(g+1)N} \tag{4}$$

$$D_1 = \frac{\lambda_n}{\mu+\eta}\left(1+\frac{g}{R}\right) \text{ and } D_2 = \frac{\lambda_h}{\mu+\eta}\left(1+\frac{g}{R}\right) \tag{5}$$

The notations D_1 and D_2 represent the call traffic for the new arrival calls and the handoff arrival calls in the cluster, respectively. The notations ω_1 and ω_2 are the traffic carried by an individual non-reservation channel per cell and a reserved channel per cell, respectively. The symbol g is the number of interference cells for a given cell, which is equal to $2(R-1)$. The notation $\lfloor x \rfloor$ in the superscript denotes the integer part of the real number x.

Then, the new call blocking probability P_b can written as

$$P_b = \sum_{j=0}^{R(M-N)} P_j b(j) + \sum_{j=R(M-N)+1}^{RM+S} P_j. \tag{6}$$

The handoff failure probability P_h can be written as

$$P_h = \sum_{j=R(M-N)+1}^{RM+S} P_j b(j) + \sum_{i=0}^{S-1} [P_{f|i} P_{RM+i}(1 - b(RM+i))] \tag{7}$$

where P_j and $b(j)$ are given by (2) and (3), respectively, and the probability $P_{f|i}$ is the failure probability [2] of a handoff arrival call initially queued at the position $(i+1)$ and it can be written as

$$P_{f|i} = \left(1 - \frac{\mu+\eta}{\mu+\gamma+2\eta}\right)\left(1 - \frac{RM(\mu+\eta)}{RM(\mu+\eta)+(\gamma+\eta)}\right) \times \prod_{k=1}^{i} \frac{(RM+k)(\mu+\eta)+k(\gamma+\eta)}{(RM+k)(\mu+\eta)+(k+1)(\gamma+\eta)} \tag{8}$$

Numerical results: Assume that the cluster size R is equal to 7. The mean call holding time $1/\mu$, the mobile dwelling mean time $1/\eta$, and the mean degradation time interval $1/\gamma$ are set to be 180, 120 and 3 s, respectively. The finite queue length for the handoff arrival calls s is equal to 6. Fig. 2 shows the call blocking probability (P_b) and handoff call failure probability (P_h) against new call arrival rate (λ_n) in a cell for $M = 16$ and $N = 5$. The probabilities P_b and P_h of DCA-GC-QH in comparison to that of the FCA-GC-QH scheme are reduced by more than 20% and 30% ($\lambda_n \le 0.2$), respectively. The simulation results of DCA-GC-QH scheme are also presented with a difference of less than 7% compared to analytical results.

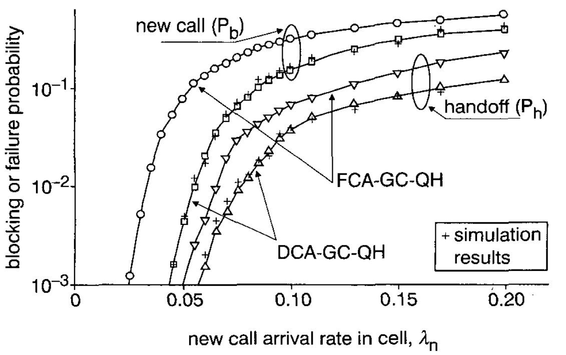

Fig. 2 *Call blocking probability (P_b) and handoff call failure probability (P_h) against new call arrival rate (λ_n) in cell ($M = 16$, $N = 5$)*

Conclusion: In this Letter, the performance analysis of dynamic channel assignment with queuing and guard channel combined scheme for handoff prioritisation (DCA-GC-QH) has been investigated. The analytical results show good agreements with the simulation results with the difference less than 7%.

5 August 2002
Electronics Letters Online No: 20021177
DOI: 10.1049/el:20021177

Zhi Hua Zheng and W.H. Lam (*Dept of Electrical and Electronic Engineering, The University of Hong Kong, Hong Kong*)

References

1 HONG, RAPPAPORT, : 'Traffic model and performance analysis for cellular mobile radio telephone systems with prioritized and nonprioritized handoff procedures', *IEEE Trans. Veh. Technol.*, 1986, **35**, pp. 77–92
2 RE, E., FANTACCI, R., and GIAMBENE, G.: 'Performance evaluation of different resource management strategies in mobile cellular networks', *Telecommun. Syst.*, 1999, **12**, pp. 315–340
3 ZHENG, ZHI HUA, and LAM, W.H.: 'Analytical methods to calculate performance of handoff prioritization in dynamic channel assignment', *Electron. Lett.*, 2001, **37**, pp. 978–979
4 KUEK, S.S., and WONG, W.C.: 'Ordered dynamic channel assignment scheme with reassignment in highway microcells', *IEEE Trans. Commun.*, 1992, **41**, pp. 271–276

Performance of LSE-RLS-based interference cancellation scheme for STBC multiuser systems

V. Mahinthan, B. Kannan and A. Nallanathan

An interference cancellation based on the least square error-recursive least square (LSE-RLS) scheme for space-time block coded (STBC) multiuser systems is presented. This scheme does not require any explicit knowledge of the channel and interference to suppress the interference.

Introduction: The space-time block code (STBC) was introduced in [1] for two transmit and multiple receive antennas. It was further developed in [2] for three and four transmit antennas from orthogonal designs. In [3], the spatial and temporal properties of STBC have been exploited to develop efficient interference cancellation techniques that can be used to increase the system capacity or to increase the system throughput for individual users and a minimum mean squared error (MMSE) interference cancellation technique has been developed for the scheme proposed in [1]. The effectiveness of interference cancellation for the STBC multiuser systems in [3] relies on the accuracy of channel estimation available at the receiver. In this Letter, an interference cancellation based on the LSE-RLS scheme for STBC multiuser systems is presented. This scheme does not require any explicit knowledge of the channel and interference to suppress the interference and the complexity of this scheme is less than the scheme described in [3].

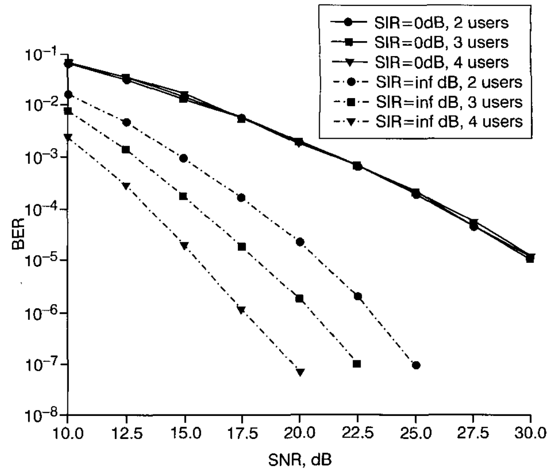

Fig. 1 *BER performance for two, three and four users, each user equipped with two transmit antennas*

System model: Consider a multiuser environment with M synchronous co-channel users where each user is equipped with N_t transmitting antennas. The receiver is equipped with M receive antennas to suppress the interference from the co-channel interferers without sacrificing the diversity order obtained by STBCs. It has been shown in [3] that only M antennas are required at the receiver to suppress the interference from the $(M-1)$ co-channel users. A space-time block code is defined by a $p \times N_t$ transmission matrix [2]. The entries of the transmission matrix for the ith user are linear combinations of variables $c_{i,l}$ and their conjugates, where $l = 1, 2, \ldots, L$. The rate R of the code is defined as $R = L/p$. In this Letter, the rate one code proposed in [1] for two transmit antennas and the rate half codes proposed in [2] for three and four transmit antennas are considered. Let $h^i_{j,k}$ denote the flat fading path gain between the jth transmit antenna and the kth receive antenna for the ith user. The received signal at the kth receive antenna during two successive symbol durations for a two transmit antenna system can be written as

$$r_{k,1} = \sum_{i=1}^{M} (h^i_{1,k} c_{i,1} + h^i_{2,k} c_{i,2}) + \eta_{k,1}$$

and

$$r_{k,2} = \sum_{i=1}^{M} (-h^i_{1,k} c^*_{i,2} + h^i_{2,k} c^*_{i,1}) + \eta_{k,2} \tag{1}$$

where the noise $\eta_{k,1}$ and $\eta_{k,2}$ are modelled as a zero-mean complex Gaussian process with variance (0.5γ) per complex dimension where γ is SNR at the receiver. The received signal could be written in matrix form as

$$\boldsymbol{r} = \boldsymbol{H} \cdot \tilde{\boldsymbol{C}} + \eta \tag{2}$$

where

$$\boldsymbol{r} = \begin{bmatrix} r_{1,1} & r^*_{1,2} & \cdots & r_{M,1} & r^*_{M,2} \end{bmatrix}^T = \begin{bmatrix} r_1 & r_2 & \cdots & r_{2M} \end{bmatrix},$$

$$\boldsymbol{H} = \begin{bmatrix} \boldsymbol{H}^1_1 & \cdots & \boldsymbol{H}^M_1 \\ \vdots & \ddots & \vdots \\ \boldsymbol{H}^1_M & \cdots & \boldsymbol{H}^M_M \end{bmatrix}, \quad \tilde{\boldsymbol{C}} = \begin{bmatrix} \boldsymbol{C}_1 \\ \vdots \\ \boldsymbol{C}_M \end{bmatrix}$$

$$\eta = \begin{bmatrix} \eta_{1,1} & \eta^*_{1,2} & \cdots & \eta_{M,1} & \eta^*_{M,2} \end{bmatrix}^T,$$

$$\boldsymbol{H}^i_k = \begin{bmatrix} h^i_{1,k} & h^i_{2,k} \\ h^{i*}_{2,k} & -h^{i*}_{1,k} \end{bmatrix} \text{ and } \boldsymbol{C}_i = \begin{bmatrix} c_{i,1} \\ c_{i,2} \end{bmatrix}$$

To suppress the co-channel interference on the first user, the least squared error (LSE) due to the co-channel interference and the noise in