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Performance analysis of multimedia communications hard handoff over fading channel

الأداء التحليلي لتناوب قنوات الاتصال في شبكات الاتصالات اللاسلكية متعددة الأوساط تحت تأثير الخفوت

Eng. Hala Bahy-Eldeen Nafea, Ass. Prof. Sherif E. Kishk, and Prof. Fayez Wanis Zaki.
Department of Electronics and Communications Engineering
Faculty of Engineering, Mansoura University
Mansoura, EGYPT

الملخص العربي: يعتبر تناوب قنوات الاتصال عنصر أساسي في منظومة الاتصالات الخلوية. وتعتبر كفاءة خوارزميات تناوب قنوات الاتصال هي الطريقة المؤثرة لتحسين سعة و جودة خدمة نظم الاتصالات الخلوية.ونظرا لأهمية خواص البث وكونها تتغير من مكان إلى اخر وكذلك من وقت لأخر ومدى تأثيرها على الإشارة وبالتالي تأثيرها على كفاءة الأداء للشبكة.كان من المهم في هذا البحث أن نتناول بالدراسة أداء طريقة لتناوب قنوات الاتصال باستخدام الطوبرة للاتصالات متعددة الأوساط(SPMC-queuing) للمفاضلة بينها وبين طرق مختلفة لتناوب قنوات الاتصال كطرق عدم الأولوية(No priority) وطريقة سابقة من طرق الطوبرة(queuing-FIFO)في وجود بعض تقنيات البث مثل ظاهرة الخفوت الظل(shadow fading) و (ricean fading) ومن خلال المحاكاة تظهر نتيجة هذه الدراسة كمدى احتمالية قطع المكالمات المتناوبة أثناء إجرائها(handoff dropping probability p_d)أو الرفض للمكالمات الجديدة التي تدخل إلى المنظومة (new call blocking probability p_b) والنتائج النهائية للبحث أثبتت مدى تأثير الخفوت (fading)على مدى جودة الخدمة لمنظومة الاتصالات الخلوية بحيث أن الطريقة لتناوب قنوات الاتصال (SPMC)أثبتت كفاءتها في تقليل نسبة انقطاع المكالمات المتناوبة متعددة الأوساط بنسبة ١٨% مقارنة بطرق عدم الأولوية (No priority) في حالة عدم وجود خفوت(no fading) بينما تعطي كفاءة بنسبة تتراوح من ٨% - ١٨% فقط في حالة وجود خفوت (shadow fading)و تعطي كفاءة اقل في حالة وجود(ricean fading) بنسبة من ٤% - ١٤% فقط.

Abstract: Handoff is an essential element of cellular communication systems. Efficient handoff algorithms can be considered as a cost-effective way of enhancing the capacity and the quality of service (QoS) of cellular systems. In this paper, the performance of no priority schemes and first- in- first -out (FIFO) handoff queuing schemes are considered. The performance of signal power multimedia communications (SPMC) is studied for multimedia communications queuing over a shadow and ricean fading channel. Computer simulations are performed to calculate the probability of new call blocking (p_b) and probability of handoff dropping (p_d) using different types of handoff strategies. Results indicate that the developed scheme reduce the probability of multimedia handoff call dropping as compared to no priority schemes with 18% in case of no fading, while it provides about 8% - 18% improvement in case of shadow fading channel, and it provides about 4% -14% improvement in case of ricean fading channel.

Key words—Multimedia wireless networks, cellular communications, handoff queuing, quality of service, radio propagation models, shadow fading, ricean fading.

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I. Introduction

Handoff is the process of transferring a mobile station from one base station to another. This process is unavoidable in every mobile communication system.

A mobile unit (MU) requests a handoff when:

- Its received signal power (RSP) is below a minimum handoff threshold level.
- Another base station (BS) exists which can provide a higher RSP than the current base station.

A typical toplogy for wireless networks is organized into geographical regions called cells [1]. The mobile users in a cell are served by a base station. However, wireless networks have to provide support for multimedia services (video, voice, and data). Moreover, in the mobile communications environment, signal propagation is affected by path loss, shadowing fading, large scale fading, and multipath fading. Path loss and shadowing are changing comparatively slow, on the other hand, the multipath fading varies fast. As such, it is important that the network guarantees a certain level of quality of service (QoS). Satisfying the required QoS is hard due to user mobility. When a mobile user moves from one cell to another, and the new cell does not have enough resources to accommodate the user, the service will be disrupted. Therefore, to maintain the service to a user, either a sufficient resource is reserved in each cell or the handoff user is selected such that the high priority user gets a better service. This study focuses on the handoff procedure of the wireless networks over a shadow and Ricean fading channel.

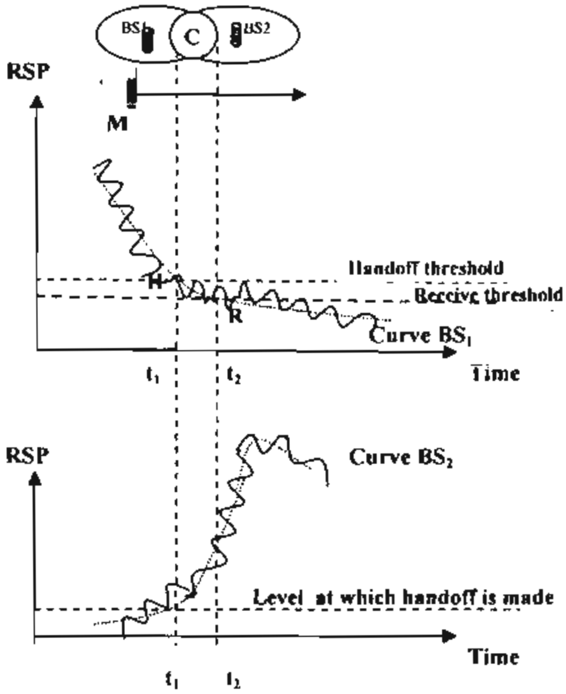

Fig. 1 Handoff and RSP.

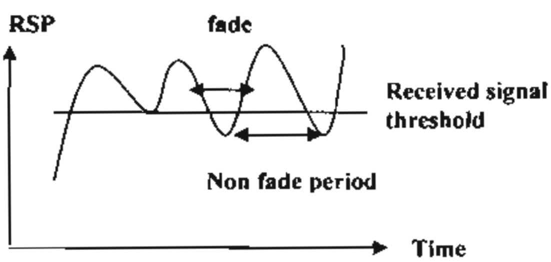

Fig. 2 Fade and non-fade duration for a sample of a fading signal.

Fig.1 shows two base stations BS_1 and BS_2 serving two cells. There are overlapping shaded area denoted by C. Assume a mobile user M moves from base station BS_1 to base station BS_2. The received signal power (RSP) from this user viewed by base station BS_1 is decreasing (curve BS_1 in Fig.1) while, the RSP viewed by base station BS_2 is increasing (curve BS_2 in Fig.1). When the RSP in the base station BS_1 is below the handoff threshold level (point H in Fig.1), a handoff request is sent to the base station BS_2. If base station BS_2 don't have enough available bandwidth for serving the mobile user M and the RSP in the base station BS_1 degrades to the receive threshold level (point R in Fig.1), the call of mobile user M will be disrupted.

Practically when mobile user M is shielded from base station by obstacles such as buildings, hill, trees or other structures, the path loss depends on the location of the receiving antenna [2]. So, obstacles and reflecting surfaces in the vicinity of the antenna have a substantial influence on the characteristics of the propagation path. Moreover, the propagation characteristics change from place to place. As shown in Fig 2, the received signal power experiences periods of sufficient signal power or "non-fade intervals" and insufficient signal power or "fades". Fading have effect on the amplitude of signal as attenuation of RSP [3]. Therefore, when the RSP is below the received threshold, then the new call or handoff request is forced to terminate. Therefore, the probability of handoff call dropping p_d and new call blocking probability p_b are high as compared to the case of no fading.

There are some approaches reported in literature to ensure that base station BS_2 (in Fig.1) has enough bandwidth to handle the handoff call request such as call admission control schemes which restrict the number of new calls accepted to decrease the probability of handoff call failure [4], [5]. Guard channel schemes which reserve a fixed or dynamically adjustable number of channel in every cell for handoff request [6], also, channel assignment schemes that reserve bandwidth only in those cells where the mobile users are expected to visit in the near future. These can be classified into fixed, dynamic, and flexible. Handoff queuing scheme is a way of delaying handoff request if the target BS is busy until a channel becomes available [7-10].There are more types of queuing scheme such as FIFO executed as first handoff request is the first handoff served [11]. Measurement based prioritizing scheme (MBPS) is used to improve FIFO queuing for which the priority is based on the RSP of an MU'S. In such cases assigning priority such that MU'S with weaker RSP are handed off first [12]. Signal prediction priority queuing (SPPQ) is adopted to improve MBPS which uses both RSP and the change in RSP (ΔRSP) to determine the priority ordering of an MU[11], [13-15], (SPPQ) queuing scheme is proposed for (SPMC) to handle the multimedia traffic using simplified path loss model without incorporation of shadowing nor multipath fading (as previously stated in [15]). As (SPMC) is highly dependant on the rate of power change, fading will have a high impact on the results proposed in [15]. In this paper, the performance of (SPMC) is studied in the presence of shadowing and multipath fading for different environments such as urban and rural areas that have different fading severness.

In the next section, performance analysis for No priority, FIFO, and the scheme signal power multimedia communications SPMC is carried out for a 16-cell network. Simulation results for SPMC indicate that it can reduce the handoff call dropping probability as compared to other methods. However, the new call blocking p_b and the handoff dropping p_d in case of fading are high as compared to fading-less propagation.

II. Simulation Model and Analysis

Here a handoff queuing scheme which focuses on the problem of handoff in multimedia communication over fading channels is introduced.

Unlike the study reported in [11], [12] where it only simulates one cell, this study investigates a network that includes 16 cells, as shown in Fig.3 for three services (voice, video, and data) The area of one cell is 4 × 4 Km^2. It is assumed that the top cells (cell 13, 14, 15, and 16) and the bottom cells(cell 1, 2, 3, and 4) are adjacent. That is if a user comes out of cell 13 from top, he will come into cell 1. Analogously, assume the left cells (cell 1, 5, 9,and 13) and right cells (cell 4, 8, 12, and 16) are adjacent too.

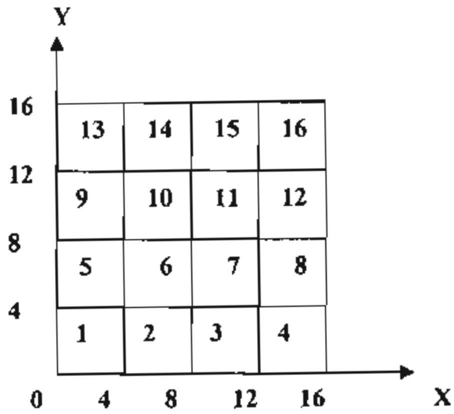

Fig. 3 Simulated wireless network

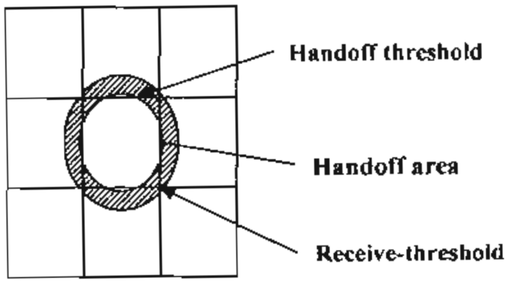

Fig. 4 Handoff threshold and receive threshold

Fig. 4 shows the concept of handoff threshold and receive threshold setting [15]. The area between handoff threshold and receive threshold is called handoff area (the shaded area of Fig. 4). Assume that the base station of each cell is located at the center of the square, and that the receive threshold is set to 2.9 Km (about half of the diagonal length) in order to cover all the cell area. The handoff threshold can be set at any distance between the cell center and the receive threshold. The handoff threshold is set to 2.7 Km. If a mobile user moves at a speed of 60 Km/hr, the mobile user will have 12 sec. for handling handoff before moving out of this handoff area [15].

The mobile users(MU's) are uniformly distributed across the coverage area. Each MU is moving in a random direction that is uniformly distributed from 0^{o} to 360^{o}. The moving speed is uniformly distributed between 30 and 90 Km. The number of channels available to each cell is 50 [15].

In this work a comparative study between No priority scheme, FIFO, SPMC is conducted. In No priority scheme, the handoff requests are treated in the same manner as the new call requests so that the probability of handoff failure(P_d) equals the probability of call blocking (P_b), which is given by the well known Erlang B formula (no queuing) for the M/M/C/C [7], [15].

$$P_b=P_d=\frac{(C\rho)^C \frac{1}{C!}}{\sum_{i=0}^{C}(C\rho)^i \frac{1}{i!}} \qquad (1)$$

Where:

C: is number of Trunked channels (servers) available .

ρ: utilization factor $\rho=\lambda/C\mu<1$

λ: the total mean call arrival rate per unit time for the entireTrunked system (average number of call request per unit time over all channel and all users). second^{-1}=call/sec

μ: the average service rate = call/sec, $\mu=1/H$.

H: The average duration of a call (average service time).

The second method FIFO and the third method SPMC, are approximated by the queuing scheme. Queues are used to hold call requests that are initially blocked. When a user attempts a call and a channel is not immediately available, the call request may be delayed until a channel becomes available. The probability that an arriving call occurs when all C channels are busy =probability that no server (C channels) are available to serve any call.

So the new call blocking probability (P_b) equals the handoff call queuing (delayed in queue) probability Pr[queuing], which is given by the well known Erlang C formula M/M/C queue. [7], [11].

P_b=Pr[queuing]=P_r[C channels are busy]=

$$\frac{(\lambda/\mu)^{C}\frac{1}{C!}}{\left(1-\frac{\lambda}{\mu C}\right)\left[\sum_{n=0}^{C}(\lambda/\mu)^{n}\frac{1}{n!}+\frac{1}{C!}(\lambda/\mu)^{C}\left(\frac{1}{1-\left(\frac{\lambda}{\mu C}\right)}\right)\right]} \quad (2)$$

Where:

λ= λ total =new call arrival rate λ_c + handoff call arrival rate λ_h

SPMC can be treated the same as FIFO but different in a handoff priority for each multimedia service P(j). So, the handoff priority for handoff request j, with service class priority p_j, is calculate as

$$P(j)= p_j \times |\Delta RSP(j)| \times \frac{1}{RSP(j)} \quad (3)$$

The previous equation means that the handoff priority for every multimedia service is calculated using the static service class priority value p_j, the degradation rate of received signal power (ΔRSP), and the RSP level itself .

The value of ΔRSP is the slope of RSP curve. If a mobile is leaving a base station or is shielded from the base station, RSP(j) will get smaller, then 1/RSP(j) will get larger to promote its priority. Similarly, if ΔRSP is large, it means that the received signal power changes rapidly. A possible reason may be that the mobile is moving at a very fast speed or there are some obstacles and reflecting surfaces in the vicinity of the mobile's antenna. So, a handoff request with a higher static service class priority or a larger ΔRSP value or a smaller RSP value will get a higher priority than other handoff requests.

The calculation of the received signal power RSP is different according to the propagation environment, so the next formula describes the received signal power RSP in the absence of fading [7].

$$RSP = \left(\frac{d_o}{d}\right)^{n} \quad \text{watt} \quad (4)$$

$$RSP = -10\, n \log\left(\frac{d}{d_o}\right) \quad \text{dbm} \quad (5)$$

Where :

n is the path loss exponent.

d_o is the reference distance for practical systems using low gain antennas. It is typically chosen to be 1m in case of indoor environments and 100 m or 1 Km in outdoor environments.

d is the distance between the transmitter and receiver.

Shadowing is a wireless phenomenon. It occurs when cell phones are inside buildings and when outside cell phones are shielded from the base station by buildings or other structures. The next formula describes the received signal power in the presence of shadow fading [7].

$$RSP_{fading} = (\frac{d_o}{d})^n 10^{\zeta/10} \quad \text{watt} \quad (6)$$

$$RSP_{fading} = -10\, n \log (\frac{d}{d_o}) + \zeta \quad \text{dbm} \quad (7)$$

Where:

ζ is zero mean Gaussian random variable with variance σ^2 for each base station.

In Multipath propagation such as Ricean fading, The signal offered to the receiver contains not only a direct line-of- sight radio wave, but also a large number of reflected radio waves. These reflected waves interfere with the direct wave, which causes significant degradation of the performance of the network. The next formula describes the Ricean distribution

$$p(r) = \left\{ \frac{r}{\sigma^2} e^{\frac{-(r^2+A^2)}{2\sigma^2}} I_0(\frac{Ar}{\sigma^2}) \right. \quad \text{for}$$

$$(A \geq 0, r \geq 0) \quad (8)$$

$$p(r) = 0 \quad \text{for} \quad (r < 0) \quad (9)$$

Where:

r is the received signal envelope voltage.

The parameter A denotes the peak amplitude of the dominant signal.

The Ricean *K*-factor k $= \frac{A^2}{2\sigma^2} =$ (the deterministic signal power/ the variance of multipath)

$I_0(..)$ is the modified Bessel function of the first kind and zero order.

III. Simulation Results

In this section, a comparative study between the performance of the developed (SPMC) strategy with FIFO, No priority schemes is presented. Both fading less channels, shadow fading channels, and Ricean fading channels are considered. The system performance is calculated against new call arrival rate, the call class, and fading severness. The used system performance metrics are the dropping probabilities for handoff requests (p_d) and blocking probabilities for new connection requests (p_b). The proposed system considers like the simulation parameter in [15] that used three service classes, called class 1, class 2, and class 3. The required bandwidth for each service classes is 64, 64×2, and 64×4 kb/s, respectively. The connection mean duration time for each class is 60, 60×5, and 60 × 15 s, respectively. The handoff priority for each class is 1, 4, and 8, respectively, and the channel capacity of a cell is 50× 64 kb/s. All the simulations are done with arrival rate ratio of, 40 : 10 : 1, for service classes 1, 2, and 3. That is to say, if the new call arrival rate is 51 calls per second, there will be 40 calls of class 1, 10 calls of class 2 and 1 call of class 3 [15].

a- Simulation without Fading

Both SPMC, FIFO, and No priority schemes are compared using a fading-less channels using the system illustrated in Fig. 3. In the first set of experiments the system performance is tested against the call arrival rate for the different call classes using the three handoff schemes. Figs. 5(a, b, c) and Figs. 5(d, e, f) show, the results reported in [15] for the new call blocking probability p_b and the handoff call dropping probability p_d of three service classes versus different offered load, respectively. According to these results, the blocking probability P_b of SPMC is almost the same as that of FIFO, of course P_b for SPMC and FIFO schemes is increasing with 0.5%-18% as compared to no priority schemes for different classes. The SPMC method reduces handoff call dropping probability for every multimedia service class, and the SPMC is effective in reducing class3's handoff call dropping probability by percent 18% more than other classes specially class1's, because class3's have a highest handoff priority and longest connection mean duration time.

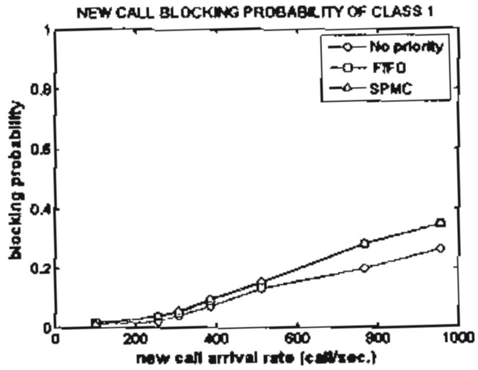

Fig.(5-a)

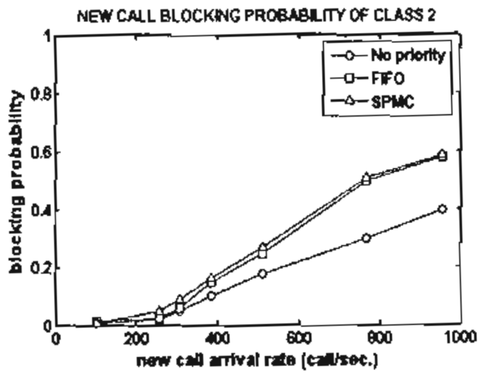

Fig.(5-b)

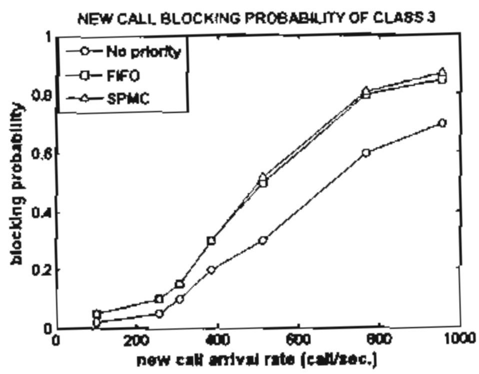

Fig.(5-c)

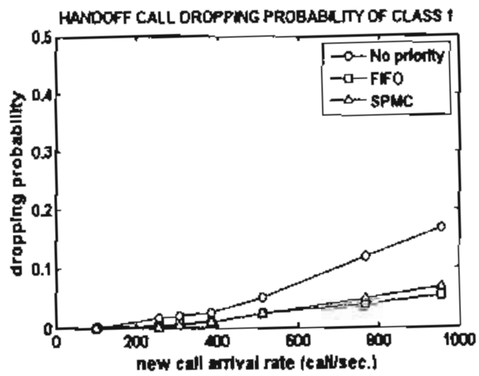

Fig.(5-d)

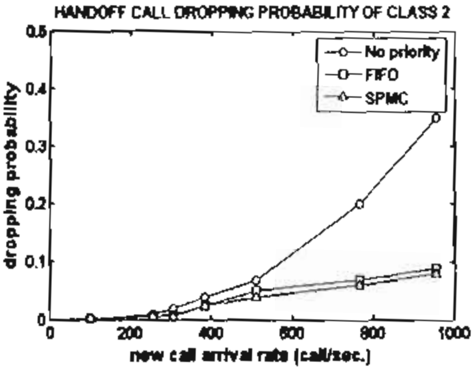

Fig.(5 -e)

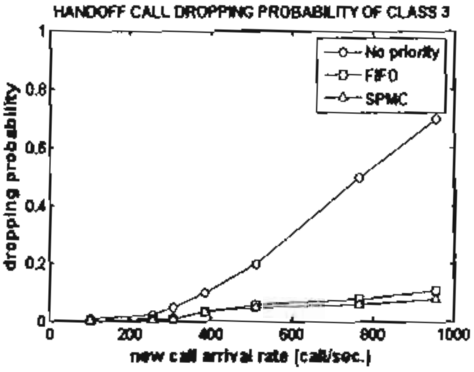

Fig.(5-f)

Fig.5. The system performance against the call arrival rate in fading-less channel (a) P_b for class1. (b) P_b for class2. (c) P_b for class3. (d) P_d for class1. (e) P_d for class2. (f) P_d for class3 after [15].

b-Simulation with Shadow Fading

The propagation characteristics change from place to place, and from time to time. So the propagation environments in urban and rural have different values of standard deviation σ.

In this section the computer simulation has been conducted for both SPMC, FIFO, and No priority schemes using a shadow fading channels when σ equal 4dB using the system illustrated in Fig.3 the study in this part is introduced by the authors of the present work. In the first set of experiments the system performance is tested against the call arrival rate for the different call classes using the three handoff schemes. Figs. 6(a, b, c) and Figs. 6(d, e, f) show, the results including the new call blocking probability p_b and the handoff call dropping probability p_d of three service classes versus different offered load, respectively. Note that handoff dropping probability p_d and the new call blocking probability p_b in case of fading are increasing about 4% - %5.5 and 2% - 2.5% as compared to p_d and p_b respectively in case of fading less channels for three handoff schemes. The SPMC method reduces handoff call dropping probability for every multimedia service class in the presence of fading as the same as the absent fading, and the SPMC is effective in reducing class3's handoff call dropping probability about 8% -18% more than other classes specially class1's, because class3's have a highest handoff priority and longest connection mean duration time.

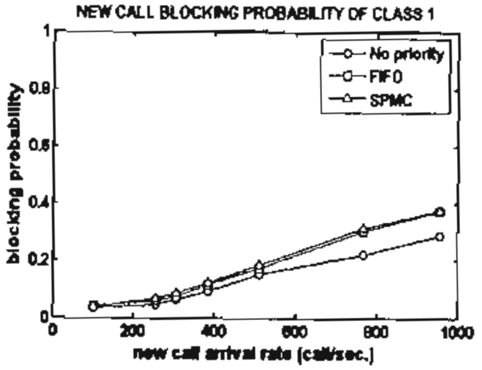

Fig.(6-a)

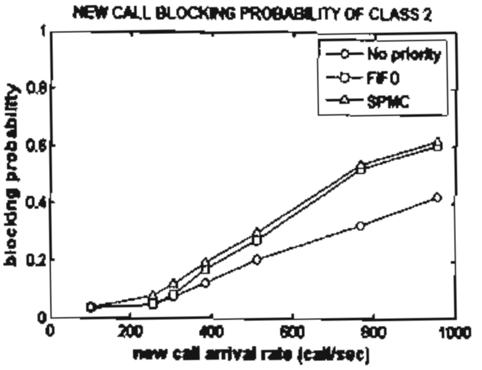

Fig.(6-b)

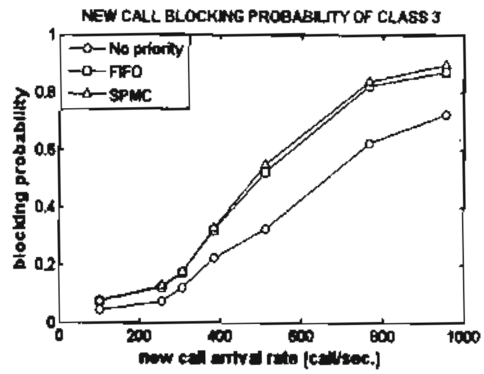

Fig.(6-c)

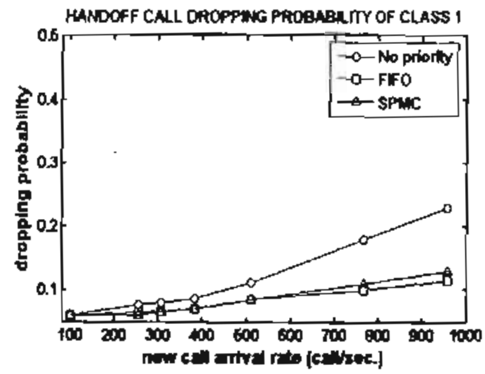

Fig.(6-d)

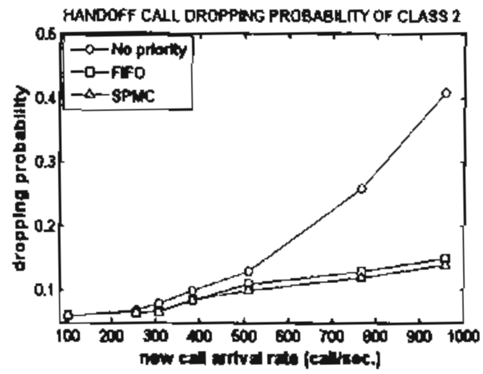

Fig.(6-e)

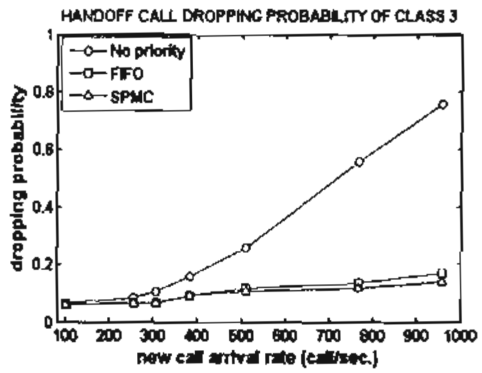

Fig.(6-f)

Fig.6. the system performance against the call arrival rate in case of shadow fading with σ equal 4dB. (a) P_b for class1. (b) P_b for class2. (c) P_b for class3. (d) P_d for class1. (e) P_d for class2. (f) P_d for class3.

c-Simulation with Ricean Fading

Multipath propagation such as Ricean fading leads to rapid fluctuations of the phase and amplitude of the signal if the vehicle moves over a distance.

The performance of both SPMC, FIFO, and No priority schemes are compared using a Ricean fading channels in case σ equal 4dB using the system illustrated in Fig. 3. In the first set of experiments the system performance is tested against the call arrival rate for the different call classes using the three handoff schemes. Figs. 7(a ,b, c) and Figs. 7(d, e, f) show, the results including the new call blocking probability p_b and the handoff call dropping probability p_d of three service classes versus different offered load, respectively. Note that handoff dropping probability p_d and the new call blocking probability p_b in case of Ricean fading are increasing about 3% - 4% and about 2% - 2.5% as compared to p_d and p_b respectively in case of Shadow fading channels for three handoff schemes. The SPMC method reduces handoff call dropping probability for every multimedia service class in the presence of fading as the same as the absent fading, and the SPMC is effective in reducing class3's handoff call dropping probability about 4% - 14% more than other classes specially class1's, because class3's have a highest handoff priority and longest connection mean duration time.

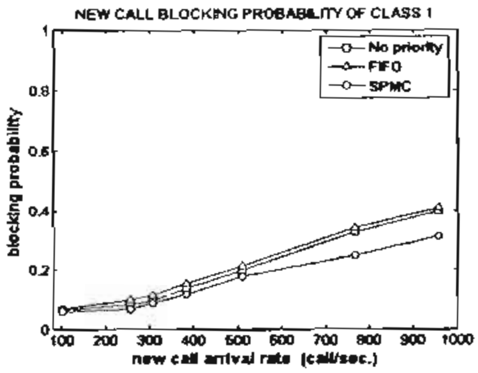

Fig.(7-a)

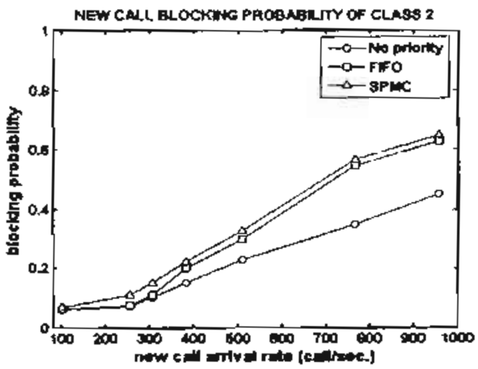

Fig.(7-b)

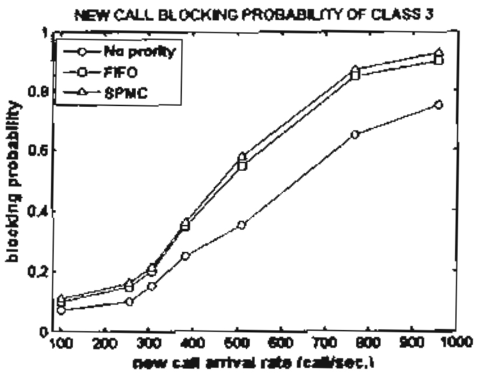

Fig.(7-c)

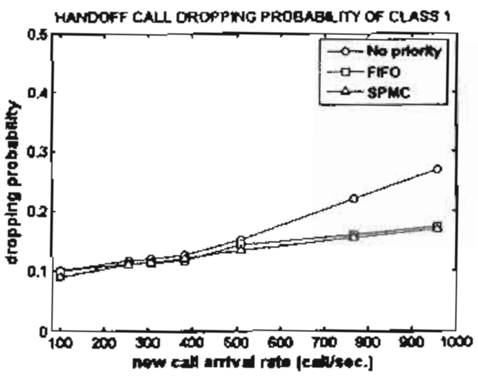

Fig.(7-d)