



Duration-Based Call Management Scheme

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Abstract: Considering some of the major challenges suffered by majority of the wireless communication network users and also the challenges being faced by the network providers in order to provide satisfactory quality of services that will meet the demand of their subscribers, there is a need for an implementation of a better call management scheme. This proposed scheme classified calls into two groups; short-calls and long-calls. Statistically, it has been found that over 65% of GSM users make calls that are less than or equal to 180s. Hence, this proposed scheme will give priority to short calls, and also adopt a relative probability factor (β) which will be used to allocate some percentage of the channels that were initially allocated to long calls whenever the long calls are minimal within the last interval being considered. This scheme tends to provide better utilisation of communication channels at all-time especially at peak periods. This paper considers the number of available channels, signal strength, short-call duration, long-call duration, call arrival rate and call service rate within the Base Transceiver Station (BTS).

Keywords: Quality of Service (QoS), Call Admission Control, Base Station Controller (BSC), Base Transceiver Station (BTS), Communication Channels, Call Duration, Mobile Station (MS)

1. Introduction

Each cell in a cellular network is equipped with a base station and with a number of radio channels assigned according to the transmission power constraints and availability of spectrum. A channel can be a frequency, a time slot or a code sequence. Any terminal residing in a cell can communicate through a radio link with the base station located in the cell, which communicates with the Mobile Switching Center (MSC), which is in turn connected to the Public Switched Telephone Networks (PSTN). When a user initiates or receives a call, the user may roam around the area covered by the network. If the mobile user moves from one cell to another, and the call from/to the user has not finished, the network has to handoff the call from one cell to another at the cell boundary crossing without user's awareness of handoff and without much degradation of the service quality [1-4]. As the demand for wireless communication systems by the users keep increasing, a good Quality of Service (QoS) is also required to manage the incoming new calls and handoff calls adequately. Radio Resource Management (RRM) plays a vital role in cellular networks to efficiently utilize the limited radio resources while guaranteeing the required QoS

for the mobile users.

Telecommunications networks aim to provide integrated services such as voice, data, and multimedia via inexpensive low-powered mobile computing devices over wireless infrastructures [5-8]. As the demand for multimedia services over the air has been steadily increasing over the last few years, wireless multimedia networks have been a very active paper area. To support various integrated services with a certain quality of service (QoS) requirement in these wireless networks, resource provisioning is a major issue [9-11].

Call admission control (CAC) is a fundamental mechanism used for QoS provisioning in a network. It is the rule to admit requested calls maintaining the quality of service for the system [12]. The design of call admission control algorithms for mobile cellular networks is especially challenging given the limited and highly variable resources, and the mobility of users encountered in such networks. CAC takes a decision whether a call should be admitted into the system with respect to the standard quality of service requirements and the current traffic load. In wireless networks, call dropping is possible due to the users' mobility. A good CAC scheme has

to balance the call blocking and call dropping in order to provide the desired QoS requirements [13]. Admission control decision is made using a traffic descriptor that specifies traffic characteristics and QoS requirements. A new call request is accepted if there is free channel in the network resource, and also if the call meets the QoS requirements of new calls without disrupting the QoS for the already supported calls. Too many calls lead to a situation where the mutual interference between the connections degrades the QoS for the new call as well as for the ongoing calls. Therefore, admission control play a very important role in providing the user with the requested QoS as well as making an efficient use of the available capacity and preventing the system from an outage situation due to overloading [14].

An accepted call that has not completed in the current cell may have to be handed off to another Base Station (BS). During the process, the call may not be able to gain a channel in the new BS to continue its service due to the limited resource in wireless networks, which will lead to call dropping. Relatively, new calls and handoff calls can be treated differently in terms of resource allocation. Since dropping a call in progress is more annoying than blocking a new call request, handoff calls are typically given higher priority than new calls in access to the wireless resources. This preferential treatment of handoffs increases the blocking of new calls and hence degrades the bandwidth utilization [15].

In order to support various integrated services with certain

quality of service requirements in these wireless networks, the study of radio resource management (RRM), radio resource provisioning (RRP), and mobility management are useful. RRM plays a vital role in cellular networks to efficiently utilize the limited radio resource while ensuring a required quality of service. The RRM involves strategies and algorithms for transmit power control, channel allocation, handoff criteria, modulation scheme, error coding schemes etc. Power control is another serious factor in network performance. It has the ability to impact the capacity and perceived quality in mobile network systems irrespective of the mode of multiple-access be it frequency or time or code division. Power control is useful in fighting the inter-cell (co-channel) interference that arises from the frequency reuse (cellular concept) [16].

2. Methods and Algorithms

In this paper, only analytical modeling and simulation of the three fundamental techniques for performance evaluation will be adopted with details in the analytical modeling approach. The need for the combination of these two techniques arises since either of the techniques cannot be relied upon to give the needed conclusion. A simulation environment in MATLAB will be used for the analysis. Thereafter, the results of the simulations will be presented in tables and graphs plots along with report on the performance variations.

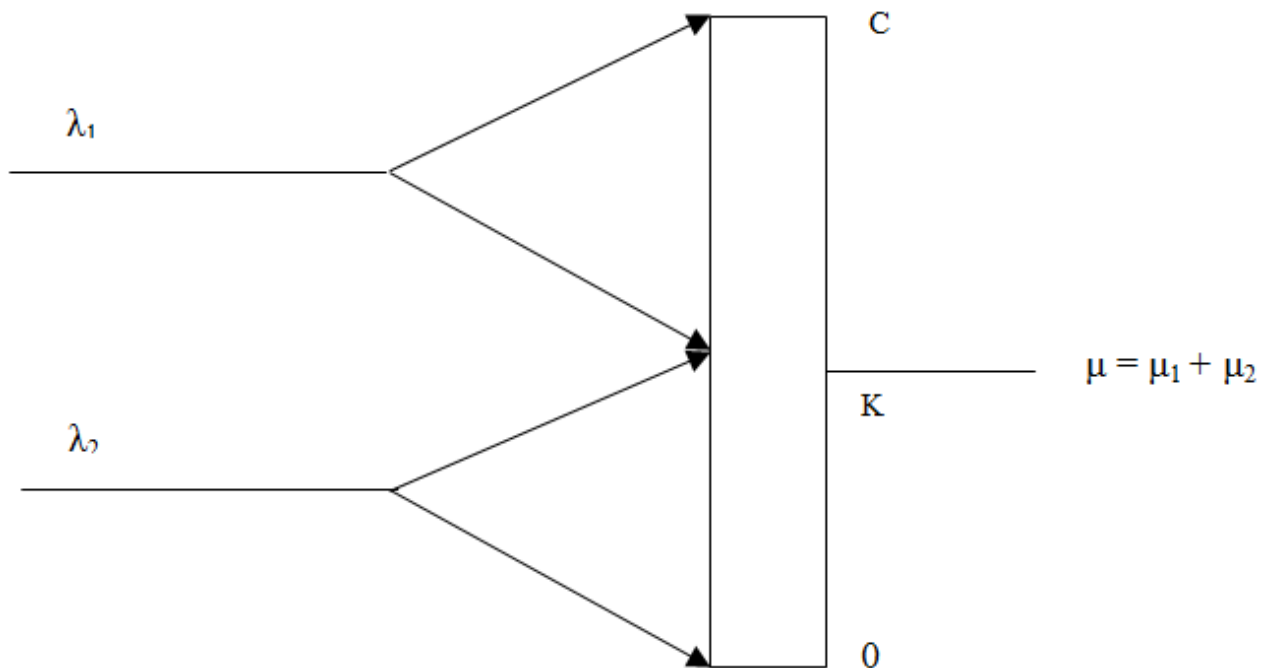


Figure 1. Simplified System model.

This proposed system model is aimed at providing better management scheme. The model shown in Figure 1 is divided into two parts; dedicated part for short calls and partially contestable part which is fundamentally for long calls. The “partially contestable” part accepts both short calls and long calls but gives priority to long calls, but uses a probability

factor (β) to determine the percentage of the free channels within this part before granting access to short calls.

Also, this proposed scheme will adopt queuing theory which in turn provides queuing mechanism for this scheme as shown in Figure 2.

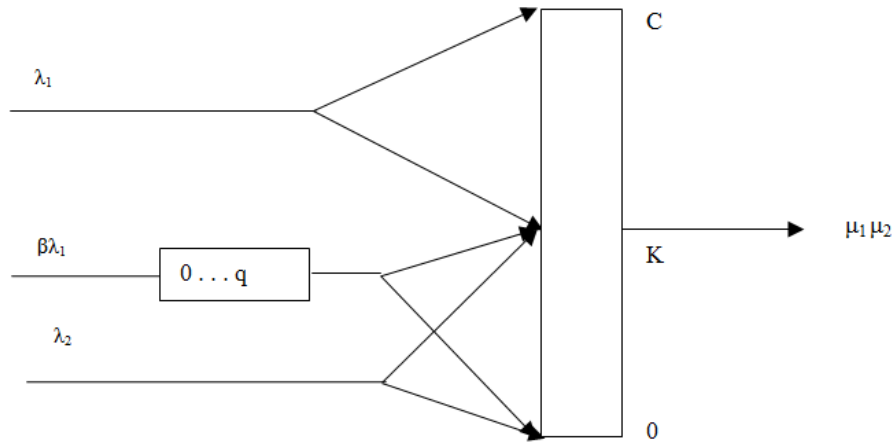


Figure 2. Modified Queuing System Model.

The states of the communication cell are represented by $0 \dots 1 \dots k \dots C$.

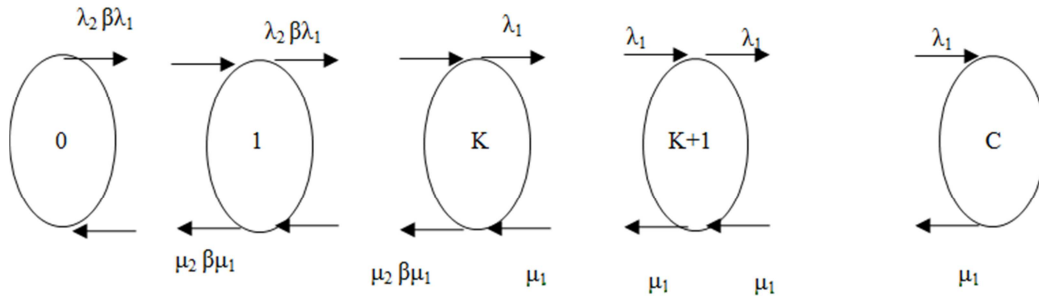


Figure 3. Transition State Diagram.

Figure 3 shows the state transition diagram for the newly proposed model shown in Figure 1, and its queuing model shown in Figure 2. This state transition diagram throws more insight on how different calls are being accepted within a particular range of channels. The symbols in Figures 1, 2 and 3 and their representations are as follow;

- i. λ stands for arrival rate,
- ii. β stands for probability factor,
- iii. λ_1 stands for short call arrival rate,
- iv. λ_2 stands for long call arrival rate,
- v. $\beta\lambda_1$ stands for relative probability factor for short call arrival rate,
- vi. μ stands for service rate,

The following assumptions were made in order to ensure adequate implementation of this new call management scheme:

- i. This proposed model is designed to be used between the hours of 5am and 12:30am.
- ii. This proposed model is designed to be flexible; the model keeps the records of all the users' call duration within the last six months, and it also has the ability to automatically change users' group in terms of either short-call user or long-call user with respect to the average number of minutes made in the last seven days.
- iii. Every new network user is initiated automatically as a short-call user for the first seven days in case of bonus and other benefits.

Let the state of the cell as the number of calls in progress for the base station containing the call be denoted as "s", where

$$s = 0, 1, 2, 3, \dots, k, (k+1), (k+2) \dots C \quad (1)$$

The probability that the BTS is in state i is given as $P(i)$, and can be solved using the birth-death process. The state balance equations as derived from the states transition diagram are as follows:

The probability that the call is in any state within the cell is given thus;

$$s\mu P(s) = \frac{\lambda^i}{\mu^i s!} P_0 \quad 0 \leq s \leq C \quad (2)$$

Therefore, the equations for the two different parts of the model are as follows;

For states "0" to "k"

$$S\mu P(s) = \lambda_2 P(s-1) \quad 0 \leq S \leq K \quad (3)$$

For states "(k+1)" to "C"

$$S\mu P(s) = \lambda_1 P(s-1) \quad (K+1) \leq S \leq C \quad (4)$$

Hence, in the normalisation condition,

$$\sum_{s=0}^C P(s) = 1 \quad (5)$$

Then, the steady state probability, $P(ss)$, is found to be:

$$\begin{cases} \frac{1}{S_1!} \left(\frac{\lambda_1}{\mu_1}\right)^{S_1} P(0)_1 & 0 \leq S \leq K \\ \frac{1}{S_2!} \left(\frac{\lambda_2}{\mu_2}\right)^{S_2} P(0)_2 & (K+1) \leq S \leq C \end{cases} \quad (6)$$

In the model, λ_1 is regarded as hotline short duration call. Therefore, a partial priority is given to such calls. If at arrival, the λ_1 finds the set of channels "K to C" occupied, the system checks for the ratio of the free channels in the "0 to K" portion. If the ratio is within a predetermined condition, $\alpha \geq 60\%$, then

the short hotline call is allocated a slot. And if the system found the condition, $\alpha \geq 60\%$, to be untrue, then the λ_1 call is put in a queue waiting for the release of a channel within the predetermined waiting time, else the call will be rejected. Hence, this slot allocation is a timer-based process.

Meanwhile, the proposed scheme can summarily be described as shown in Figure 4. This flowchart contains a symbol named alpha (α) that represents the signal strength of both the short-call and long-call.

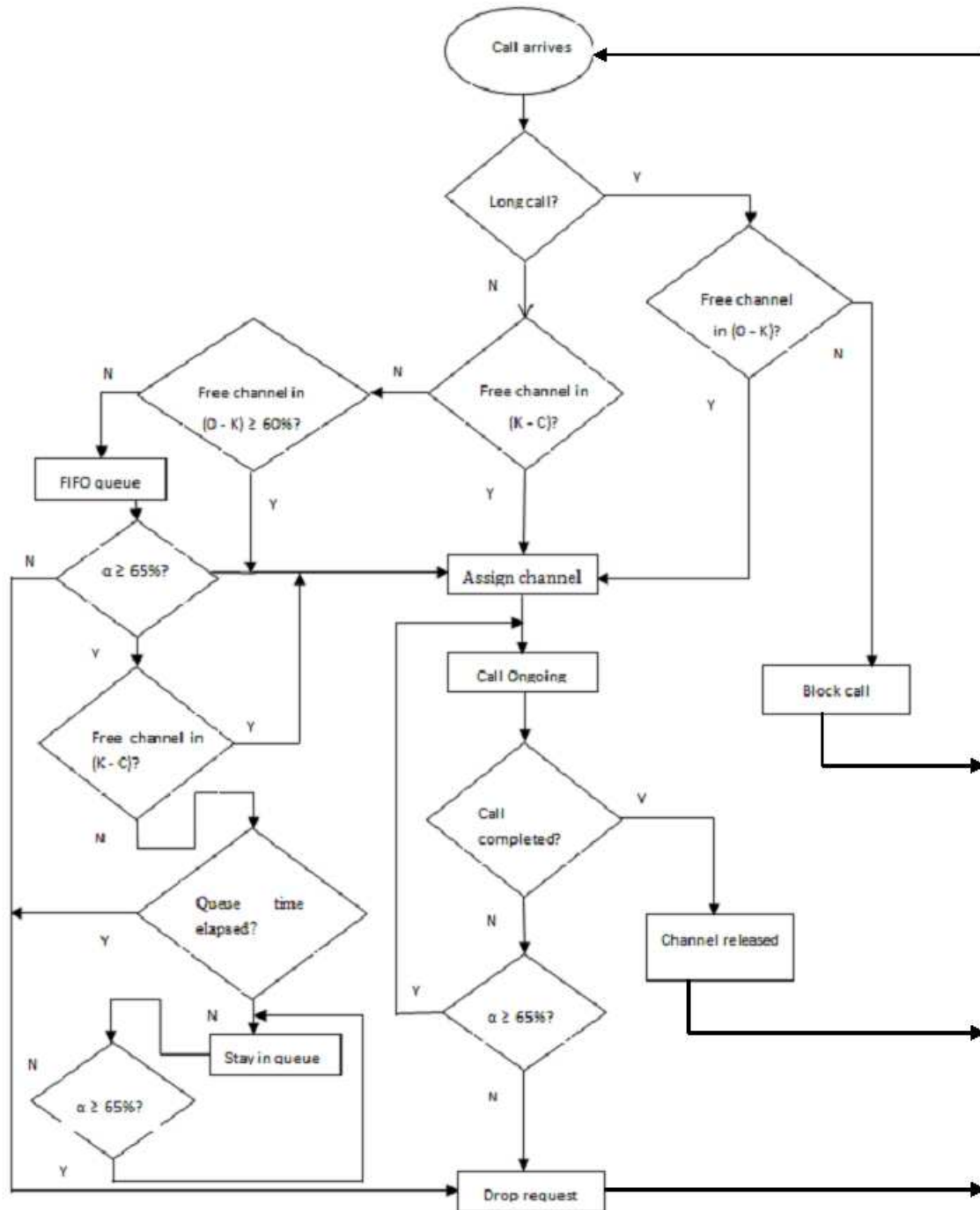


Figure 4. Flowchart for the Proposed Model.

3. Results and Discussion

The different parameters and their values or range of values are as presented in Tables 1.

Table 1. System parameters and their value(s) for simulation.

Parameters	Values
No. of channels (C)	2 – 32
Short call arrival rate (λ_1)	≥ 100 (/s)
Long call arrival rate (λ_2)	< 100 (/s)
Relative probability factor (β)	$\geq 60\%$
Call service rate (μ)	> 0
Short call duration (mean $1/\mu_1$)	≤ 180 (s)
Long call duration (mean $1/\mu_2$)	> 180 (s)
Signal strength (α)	$\geq 65\%$

Some of the graphical results are presented in this section in order to properly demonstrate the effect of this scheme in utilizing communication channels and reducing call failure probabilities. These results were obtained through MATLAB simulation.

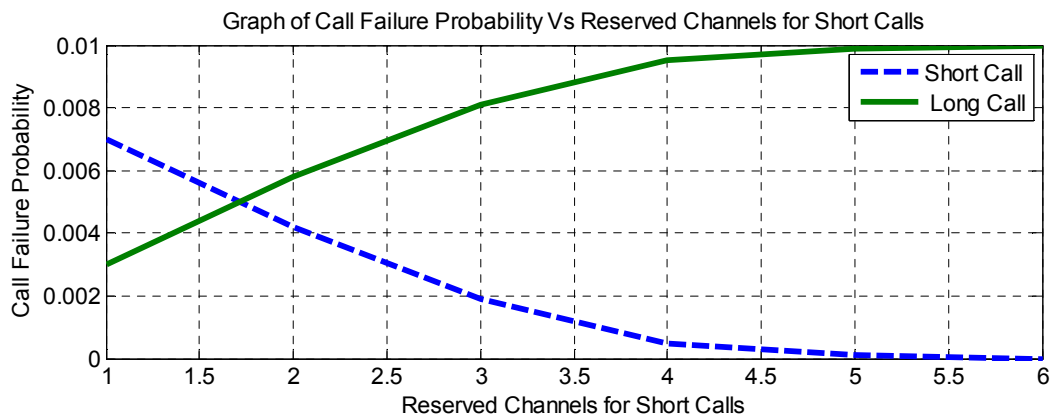


Figure 5. Graphical Result for Simulation I.

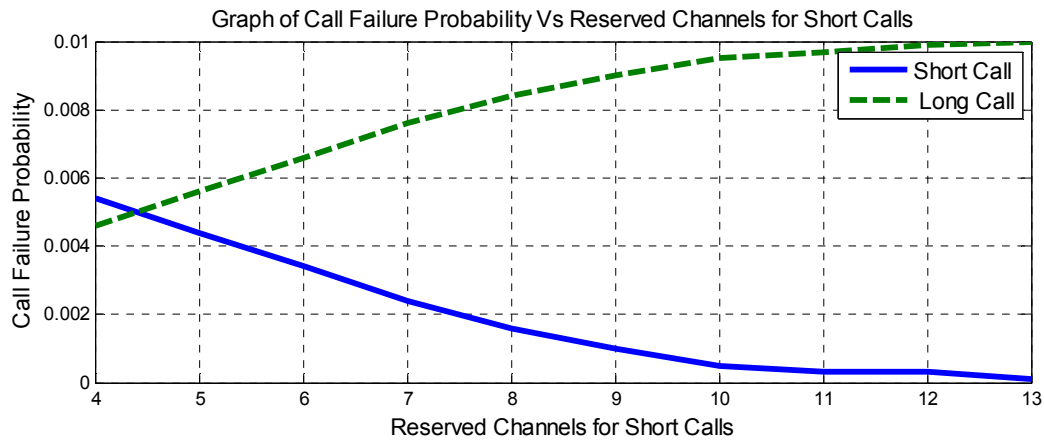


Figure 6. Graphical Result for Simulation II.

4. Conclusion

This proposed scheme considers two different kinds of calls; short-calls and long-calls, but gives priority to short-calls. The separation of calls within this paper work helps to provide one of the best channel management within a given BTS. The proposed scheme is a prioritized one which ensures better channel utilization at all time. The performance of this new scheme in terms of call failure probabilities was carried out using MATLAB software and the results were shown in

Figures 5 and 6. Also, having analyzed this newly proposed scheme with different graphical presentations shown in chapter four above, it can be clearly seen that this proposed scheme manages the available channels properly at all times. The proposed scheme is based on two ideas; that reserved or guard channels could be idle while some other calls are being rejected, and that more calls are being dropped at peak period. A relational probability factor (β) is always used to check if a short-call can be allocated a channel from the channels initially reserved for long-calls.

References

- [1] Yuzhe, Z., & Bo, A. (2014). Quality of service improvement for high-speed railway communications. *China Communications*, 11 (11), 156-167.
- [2] Bousia, A. (2016). Design of energy efficient network planning schemes for LTE-based cellular networks.
- [3] Fotouhi, H. (2015). Reliable Mobility Support in Low-Power Wireless Networks.
- [4] Cheelu, D., Babu, M. R., & Krishna, P. V. (2013). A study of vertical handoff decision strategies in heterogeneous wireless networks. *International Journal of Engineering and Technology*, 5 (3), 2541-2554.
- [5] Poletti, C., & Cartigny, M. (2015). *U. S. Patent No. 9,025,447*. Washington, DC: U. S. Patent and Trademark Office.
- [6] Valacich, J. S., Looney, C. A., Wright, R. T., & Wilson, D. W. (2013). MOBILE COMPUTING AND COLLABORATION. *Collaboration Systems: Concept, Value, and Use*, 143.
- [7] Shiraz, M., Gani, A., Khokhar, R. H., & Buyya, R. (2013). A review on distributed application processing frameworks in smart mobile devices for mobile cloud computing. *IEEE Communications Surveys & Tutorials*, 15 (3), 1294-1313.
- [8] Sharma, M., Lee, J., Prakash, R., Ahmavaara, K. I., & Radulescu, A. D. (2015). *U. S. Patent Application No. 14/811,211*.
- [9] Akhila, S., & Lakshminarayana, M. (2008). Averaging mechanisms to decision making for handover in GSM. *32nd World Academy of Sci., Eng. and Technology*.
- [10] Khodkari, H., Maghrebi, S., & Branch, R. (2016). Necessity of the integration Internet of Things and cloud services with quality of service assurance approach. *Bulletin de la Société Royale des Sciences de Liège*, 85 (1), 434-445.
- [11] Van Quang, B., Prasad, R. V., & Niemegeers, I. (2012). A survey on handoffs—lessons for 60 GHz based wireless systems. *IEEE Communications Surveys & Tutorials*, 14 (1), 64-86.
- [12] Shristop L., Marco L., & Axel T., (2004). "Adaptive Call Admission Control for QoS/ Revenue Optimization in CDMA Cellular Networks", Kluwer Academic Publishers, Wireless Networks 10,457-472.
- [13] Chang, C. J. & Lo, K. R. (1999). "Analysis of a hierarchical cellular system with reneging and dropping for waiting new calls and handoff calls." *IEEE Trans. Veh. Technol.*, vol. 48, no. 4, pp. 1080–1091.
- [14] S. A. El-Dolil, A. Y. Al-Nahari, M. I. Desouky, F. E. El-Samie, Uplink Power Based Admission Control in Multi-Cell Wcdma Networks With Heterogeneous Traffic: *Progress in Electromagnetics Paper B*, 1, (2008), 115–134.
- [15] Valko A. G. & Campbell, A. T. (2000). "An efficiency limit of cellular mobile systems." *Computer Communications Journal*, vol. 23, no. 5-6, pp. 441–451.
- [16] Liu, D., Zhang, Y. & Hu, S. (2004). Call Admission Policies On Calculated Power Control Setpoints in SIR- Based Power-Controlled DS-CDMA Cellular Networks: *Wireless Networks*, 10, 473-483.