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Research Article

Call Admission Scheme for Multidimensional Traffic Assuming Finite Handoff User

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Usually, the number of users within a cell in a mobile cellular network is considered infinite; hence, $M/M/n/k$ model is appropriate for new originated traffic, but the number of ongoing calls around a cell is always finite. Hence, the traffic model of handoff call will be $M/M/n/k/N$. In this paper, a K-dimensional traffic model of a mobile cellular network is proposed using the combination of limited and unlimited users case. A new call admission scheme (CAS) is proposed based on both thinning scheme and fading condition. The fading condition of the wireless channel access to a handoff call is prioritized compared to newly originated calls.

1. Introduction

First- and second-generation wireless cellular systems were designed mainly for voice services but integration of voice data became the major concern for third- and future generation mobile cellular systems which offer both circuit and packet switches transfer mode [1, 2]. In recent years, the demand for mobile cellular communication has grown tremendously and effort in research has been made to improve its quality of service (QoS) with the limited number of channels. The blocking probability of a new call and the forced termination probability of a handoff call are two fundamental measures in the teletraffic analysis of the mobile cellular network. In a single-service mobile cellular network, each cell usually experiences two-dimensional voice traffic: one is a new originating call of that cell and the other is a handoff call from surrounding cells. Here, both types of traffic have the same bandwidth and hence channel limitation (not bandwidth limitation) is the only consideration to combat call blocking probability.

In a multiservice system, that is, voice-data integrated networks, call admission control is a cumbersome job since effective sharing of limited bandwidth among multiple offered traffic has to be considered. One of the promising techniques of achieving optimum carried traffic gain from the statistical location of users and demand vector of a cell is the channel borrowing scheme. In this technique, each cell has the option to borrow channels from adjacent cells when the offered traffic exceeds the capacity of that cell, making smaller groups of channels to resemble a large group. In the dynamic channel allocation (DCA) technique, channels are allocated centrally among the cells based on the demand vector of each cell.

In both Fixed Channel Allocation (FCA) and DCA, environment channel reservation for handoff traffic further improves overall system performance in the context of forced termination.

Efficient integration of voice/data is presented in [3] using N-stage Markovian chain. Markov chain of the Transmission Control Protocol (TCP) over the Asynchronous Transfer Mode (ATM) is modeled in [4] and is a complete analysis of data traffic. Two state on-off techniques and their transition are summarized with mathematical derivation in [5–7] to model data traffic. To support various integrated services with a certain QoS requirement, resource allocation of limited bandwidth is a major issue and call admission control is such a provisioning scheme explained in [8, 9] explicitly. An analytical model to study the system performance of integrated voice/data mobile network with finite buffer was proposed in [10, 11] which gives a new call admission technique called "New Call Bounding Scheme" modeled by two-dimensional Markov chain with state space, $S = \{(n_1, n_2) 0 \leq n_1 \leq k,\ n_1 + n_2 \leq C\}$, where n_1 denotes the number of new calls initiated in the cell, n_2 is the number of handoff calls in the cell, K is the threshold for the new calls, and C is the capacity of the cell.

One of the key challenges in mobile cellular network is the allocation of channels for multiple services in the system. The Guard Channel (GC) scheme provides necessary QoS for a particular part of traffic like handover traffic of voice call. GC improves the probability of successful handoffs by reserving few channels for handover calls. Here, each cell has M channels assigned to it and therefore can support M simultaneous calls and m $(0 \leq m \leq M)$ channels in each cell are reserved for calls that arrive to the cell as handoffs, which is summarized in [12, 13].

An analytical model to study the system performance of integrated voice/data mobile network with finite buffer was proposed in [11]. Here, the boundary between compartments is dynamically moved such that the bandwidth can be utilized efficiently while satisfying the QoS requirements for voice and data traffic. Previous studies [14, 15] assumed homogeneous traffic where each cell has the same number of channels and experience fixed offered traffic but the proposed model of [11] accommodates heterogeneity of traffic. An Adaptive-Terminal Modality-Based Joint Call Admission Control (ATJCAC) algorithm has been proposed to reduce call blocking/dropping probability in the literature for heterogeneous wireless networks [16]. In [17], a semi-Markov decision process (SMDP) approach is presented to acquire the required QoS of mobile user in heterogeneous wireless networks by reducing the probabilities of dropping and blocking calls. The paper [18] presented the ecology-inspired Joint Admission Control (JAC) scheme that can balance the traffic and adopts the Gause-Lotka-Volterra (GLV) model to predict the heterogeneous network traffic.

Recent literature shows the multidimensional offered traffic of mobile cellular networks in two equal parts: new arrival and handoff traffic. In [19], both types of traffic are considered as $M/M/n/k/\infty$. The number of users in a particular cell can be considered as infinite. Then, the Base Station (BS) experiences a constant call arrival rate. But the BS of the cell experiences handoff calls for the surrounded cells which is finite user traffic since the number of ongoing calls around a cell is finite. Therefore, the offered traffic of a mobile cellular network is a combination of Engset and Erlang's traffic. The entire analysis of [19] is modified in this paper for k-dimensional traffic in generalized form.

The rest of the paper is organized as follows. Section 2 describes the system model under consideration. In Section 3, simulations and results from the system model are presented in the Proposed Call Admission Scheme. Finally, Section 4 concludes the paper.

2. System Model

We consider a cellular network with a total number of channels M which supports k service classes. As we are considering both new and handoff requests, there are a total of $2k$ arrival types. New and handover arrivals of the jth service class are λ_{nj} and λ_{hj}, which happens according to Poisson process. The call holding time (CHT) rates for new and handoff arrivals of the jth service class are denoted by μ_{nj} and μ_{hj}.

Let the number of new originating calls of the jth service class be n_{nj} and that of handoff calls of the jth service class be n_{hj}. Now, the probability state of k-dimensional traffic of unlimited user case is

$$P_{x_1,x_2,\ldots,x_k} = \frac{\prod_{i=1}^{k}\left(\left(A_i\right)^{x_i}/x_i!\right)}{\sum_{y_1=0}^{M}\sum_{y_2=0}^{M-y_1}\sum_{y_3=0}^{M-y_1-y_2}\cdots\sum_{y_k=0}^{M-y_1-y_2-\cdots-y_{k-1}}\prod_{i=1}^{k}\left(\left(A_i\right)^{y_i}/y_i!\right)}. \quad (1)$$

For k-dimensional limited user traffic, the above equation can be written as

$$P_{x_1,x_2,\ldots,x_k} = \frac{\prod_{i=1}^{k}C\left(N_i x_i\right)\times a_i^{x_i}}{\sum_{y_1=0}^{M}\sum_{y_2=0}^{M-y_1}\sum_{y_3=0}^{M-y_1-y_2}\cdots\sum_{y_k=0}^{M-y_1-y_2-\cdots-y_{k-1}}\prod_{i=1}^{k}C\left(N_i x_i\right)\times a_i^{y_i}}, \quad (2)$$

where N_i is the number of users of ith traffic and a_i is the offered traffic per user of ith traffic.

Let us consider a case of traffic of a particular cell of a mobile cellular network where two different arrival traffic types of new originating call are A_{n1} and A_{n2} and those of handoff are a_{h1} and a_{h2} per user, respectively. If the average numbers of users corresponding to traffic types a_{h1} and a_{h2} surrounding the cell are N_1 and N_2, then any probability state can be written as

$$P_{x_{n1},x_{n2},x_{h1},x_{h2}} = \frac{\left({A_{n1}}^{x_{n1}}/x_{n1}!\right)\cdot\left({A_{n2}}^{x_{n2}}/x_{n2}\right)\left[a_{h1}^{x_{h1}}\cdot C\left(N_1 x_{h1}\right)\cdot a_{h2}^{x_{h2}}\cdot C\left(N_2 x_{h2}\right)\right]}{\sum_{i=1}^{M}\sum_{j=0}^{M-i}\sum_{k=0}^{M-i-j}\sum_{r=0}^{M-i-j-k}\left[\left({A_{n1}}^{i}/i!\right)\cdot\left({A_{n2}}^{j}/j!\right)\left[a_{h1}^{k}\cdot C\left(N_1 k\right)\cdot a_{h2}^{r}\cdot C\left(N_2 r\right)\right]\right]}. \quad (3)$$

Now, the probability of reaching a complete occupied state is

$$B = \sum_{i=1}^{M}\sum_{j=0}^{M-i}\sum_{k=0}^{M-i-j}P\left(i,j,k,M-i-j-k\right). \quad (4)$$

Now, the generalized form of (3) is

$$P_{x_1,x_2,\ldots,x_k,y_1,y_2,\ldots,y_k} = \frac{\prod_{i=1}^{k}\left(A_i{}^i/i!\right)\cdot C\left(N_i i\right)a_i^i}{\sum_{x_1=1}^{M}\sum_{x_2=0}^{D_1}\cdots\sum_{x_k=0}^{D_2}\sum_{y_1=0}^{D_3}\sum_{y_2=0}^{D_4}\sum_{y_2=0}^{D_5}\cdots\sum_{y_k=0}^{D_6}\left[\prod_{i=1}^{k}A_i^{x_i}a_i^{y_i}C\left(N_{y_i}y_i\right)\right]}, \quad (5)$$

where

$$\begin{aligned}
D_1 &= M - x_1,\\
D_2 &= M - x_1 - x_2\cdots x_{k-1},\\
D_3 &= M - x_1 - x_2\cdots x_{k-1} - x_k,\\
D_4 &= M - x_1 - x_2\cdots x_{k-1} - x_k - y_1,\\
D_5 &= M - x_1 - x_2\cdots x_{k-1} - x_k - y_2,\\
D_6 &= M - x_1 - x_2\cdots x_{k-1} - x_k - y_2\cdots y_{k-1}.
\end{aligned} \quad (6)$$

Let us now apply a CAS using the concept of thinning scheme where a handoff call can access the logical channel in case of availability of channel. Although the fading effect of the wireless channel deteriorates the voice mobility (increases the bit error rate for data traffic), the effect is ignored to combat force termination. In case of a new originating call, small-scale fading is considered so as to provide the service; hence, the arrival rate of a new originating call is weighted by a probability $Q(x_i)$ given in (7).

Now, if we consider that the cannel is Rayleigh distributed, then the outage probability (incorporating the number of users) in normalized form can be written as

$$Q_{\text{Rayleigh}}\left(x_i\right) = \frac{1}{\gamma_{av}\cdot x_i}\cdot e^{-\gamma/(\gamma_{av}\cdot x_i)}. \quad (7)$$

Applying CAS, now the probability state becomes

$$P_{x_1,x_2,\ldots,x_k} = \frac{\prod_{i=1}^{k}\left(\left[Q_{\text{Rayleigh}}\left(x_i\right)A_i\right]^{x_i}/x_i!\right)}{\sum_{y_1=0}^{M}\sum_{y_2=0}^{M-y_1}\sum_{y_3=0}^{M-y_1-y_2}\cdots\sum_{y_k=0}^{M-y_1-y_2-y_{k-1}}\prod_{i=1}^{k}\left(\left[Q_{\text{Rayleigh}}\left(x_i\right)A_i\right]^{y_i}/y_i!\right)}. \quad (8)$$

If we consider that the channel is Nakagami-m fading distributed, then in this case the outage probability in normalized form can be written as

$$Q_{\text{Nakagami-}m}\left(x_i\right) = \frac{m^m\gamma^{m-1}x_i^m}{\gamma_{av}^m\Gamma\left(m\right)}\cdot\exp\left(\frac{-\gamma m x_i}{\gamma_{av}}\right), \quad (9)$$

where m is known as the Nakagami fading parameter or the shape factor of the Nakagami-m distribution.

Considering the case of Nakagami-m fading in the CAS, the probability state becomes

$$P_{x_1,x_2\cdots x_k} = \frac{\prod_{i=1}^{k}\left(\left[Q_{\text{Nakagami-}m}\left(x_i\right)A_i\right]^{x_i}/x_i!\right)}{\sum_{y_1=0}^{M}\sum_{y_2=0}^{M-y_1}\sum_{y_3=0}^{M-y_1-y_2}\cdots\sum_{y_k=0}^{M-y_1-y_2-y_{k-1}}\prod_{i=1}^{k}\left(\left[Q_{\text{Nakagami-}m}\left(x_i\right)A_i\right]^{y_i}/y_i!\right)}. \quad (10)$$

Probability of reaching the complete occupied state for both fading cases can be found using (5).

3. Results and Simulations

First of all, we consider 4-dimensional traffic of a mobile cellular network: two newly originated traffic types and corresponding two handoff traffic types. Figure 1 shows the variation of blocking probability against the offered traffic of newly originating call, taking the number of users as a parameter. Here, we have taken a total number of channels $M = 12$, first newly originated offered traffic $A1 = 0.2$ to 1.5 and corresponding handoff traffic $a3 = 0.02$, and second newly originated traffic $A2 = 1$ and corresponding handoff traffic $a4 = 0.03$.

Three curves are found to be almost parallel; that is, the rate of increment of blocking probability is less sensitive compared to vertical jump of the curves along the blocking probability axis. Using similar traffic parameters, the blocking probability is also plotted against the number of channels of the Base Transceiver Station (BTS) shown in Figure 2. The impact of users on blocking probability is also variable, visualized from the separation of three curves with change in the number of channels. The separation among three curves

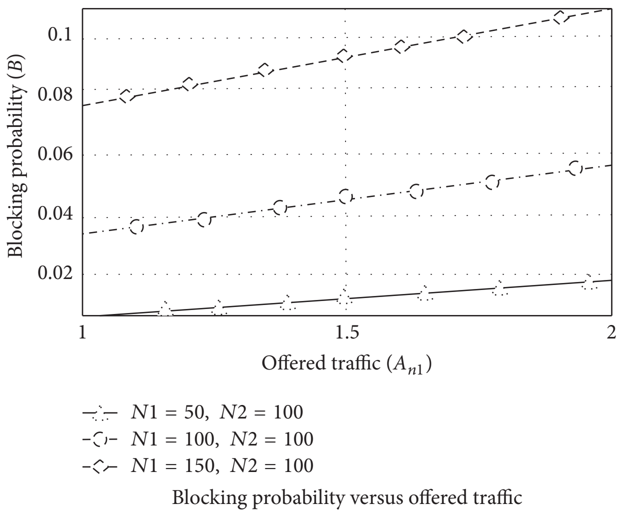

FIGURE 1: Variation of blocking probability against the offered traffic of newly originating call.

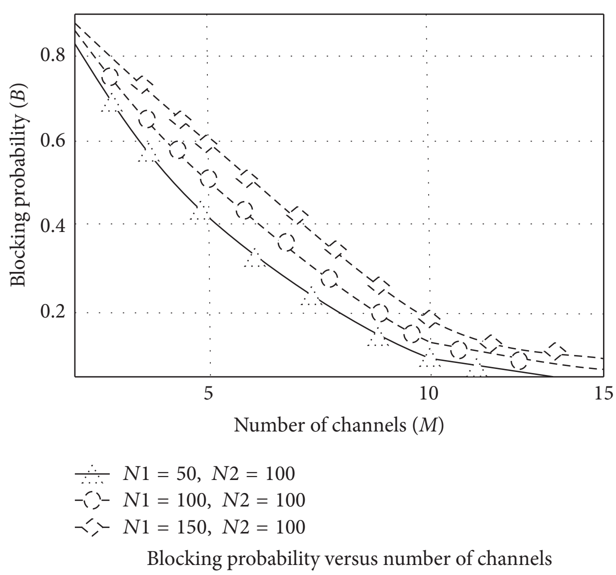

FIGURE 2: Variation of blocking probability against the number of channels of the BTS.

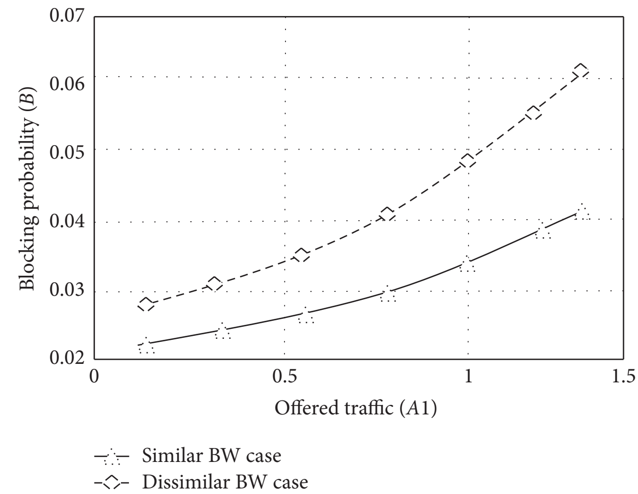

FIGURE 3: Impact of bandwidth on the blocking probability against the offered traffic (A1).

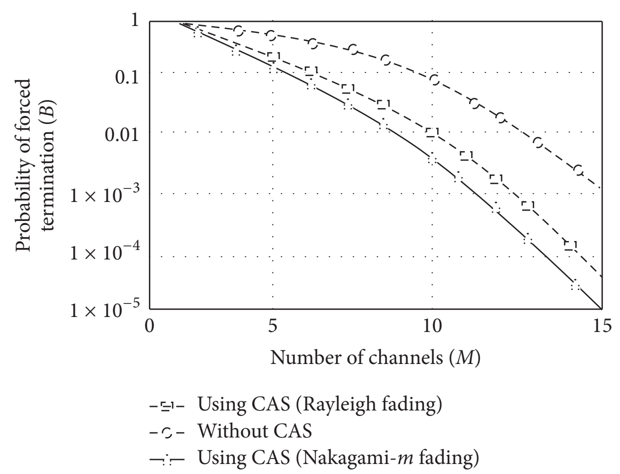

FIGURE 4: Variation of probability of forced termination against the number of channels.

has a maximum close to the region of 50% blocking. All the traffic corresponding to Figures 1 and 2 follows complete sharing access technique and these figures are of similar bandwidth.

The blocking probability of dissimilar bandwidth traffic (bandwidth of data traffic is considered twice that of voice traffic) case is shown in Figure 3 where the blocking probability is almost twice that of a similar bandwidth case.

Finally, the impact of fading is applied as thinning scheme on the traffic on the mobile cellular network to determine the probability of forced termination. In this paper, we consider Rayleigh and Nakagami-m fading on the offered traffic.

In Nakagami-m model, the condition of the wireless channel will be better than that of Rayleigh fading condition. Therefore, the tendency of providing channel to a new originating call will be enhanced. Therefore, handoff traffic will suffer more than that of Rayleigh fading condition. The situation is visualized in Figure 4.

4. Conclusions

In this paper, we considered Markovian arrival and Markovian service traffic of limited trunk for both (pure chance traffic) PCT-1 and PCT-2 traffic cases. Still, we have the scope of enhancing the paper for DOVE (Delay of Voice End-User) and DTBR (Distributed Threshold Bandwidth Reservation) and other schemes. The model is suitable for WiMax traffic of channel and user based resource assignment. We have the scope of comparing the result with the two-dimensional model of MMPP (Markov Modulated Poisson Process) $+M/G/1$ applicable in various data integrated services.

Competing Interests

The authors declare that they have no competing interests.

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References

[1] M. Shafi, A. Hashimoto, M. Umehira, S. Ogose, and T. Murase, "Wireless communications in the twenty-first century: a perspective," *Proceedings of the IEEE*, vol. 85, no. 10, pp. 1622–1638, 1997.

[2] A. C. Cleary and M. Paterakis, "On the voice–data integration in third generation wireless access communication networks," *European Transactions on Telecommunications*, vol. 5, no. 1, pp. 11–18, 1994.

[3] P. Koutsakis and M. Paterakis, "Integrating voice, video, and e-mail data packet traffic over wireless TDMA channels with errors," *International Journal of Wireless Information Networks*, vol. 8, no. 4, pp. 217–227, 2001.

[4] M. Ajmone Marsan, E. De Souza e Silva, R. Lo Cigno, and M. Meo, "A Markovian model for TCP over ATM," *Telecommunication Systems*, vol. 12, no. 4, pp. 341–368, 1999.

[5] H. W. Lee and J. W. Mark, "ATM network traffic characterization using two types of on-off sources," *Telecommunication Systems*, vol. 9, no. 2, pp. 153–171, 1998.

[6] R. Bolla, F. Davoli, and M. Marchese, "Evaluation and comparison of cell loss and delay models for ATM multiplexers," *Telecommunication Systems*, vol. 16, no. 1-2, pp. 41–54, 2001.

[7] S. K. Hwang and D. S. Kim, "Markov model of link connectivity in mobile ad hoc networks," *Telecommunication Systems*, vol. 34, no. 1-2, pp. 51–58, 2007.

[8] D. E. Everitt, "Traffic engineering of the radio interface for cellular mobile networks," *Proceedings of the IEEE*, vol. 82, no. 9, pp. 1371–1382, 1994.

[9] M. D. Kulavaratharasah and A. H. Aghvami, "Teletraffic performance evaluation of microcellular personal communication networks (PCN's) with prioritized handoff procedures," *IEEE Transactions on Vehicular Technology*, vol. 48, no. 1, pp. 137–152, 1999.

[10] Y. Fang and Y. Zhang, "Call admission control schemes and performance analysis in wireless mobile networks," *IEEE Transactions on Vehicular Technology*, vol. 51, no. 2, pp. 371–382, 2002.

[11] Y.-R. Haung, Y.-B. Lin, and J.-M. Ho, "Performance analysis for voice/data integration on a finite-buffer mobile system," *IEEE Transactions on Vehicular Technology*, vol. 49, no. 2, pp. 367–378, 2000.

[12] W. Li and A. S. Alfa, "Channel reservation for handoff calls in a PCS network," *IEEE Transactions on Vehicular Technology*, vol. 49, no. 1, pp. 95–104, 2000.

[13] P.-O. Gaasvik, M. Cornefjord, and V. Svensson, "Different methods of giving priority to handoff traffic in a mobile telephone system with directed retry," in *Proceedings of the 41st IEEE Vehicular Technology Conference*, pp. 549–553, IEEE, St. Louis, Mo, USA, May 1991.

[14] F.-N. Pavlidou, "Two-dimensional traffic models for cellular mobile systems," *IEEE Transactions on Communications*, vol. 42, no. 234, pp. 1505–1511, 1994.

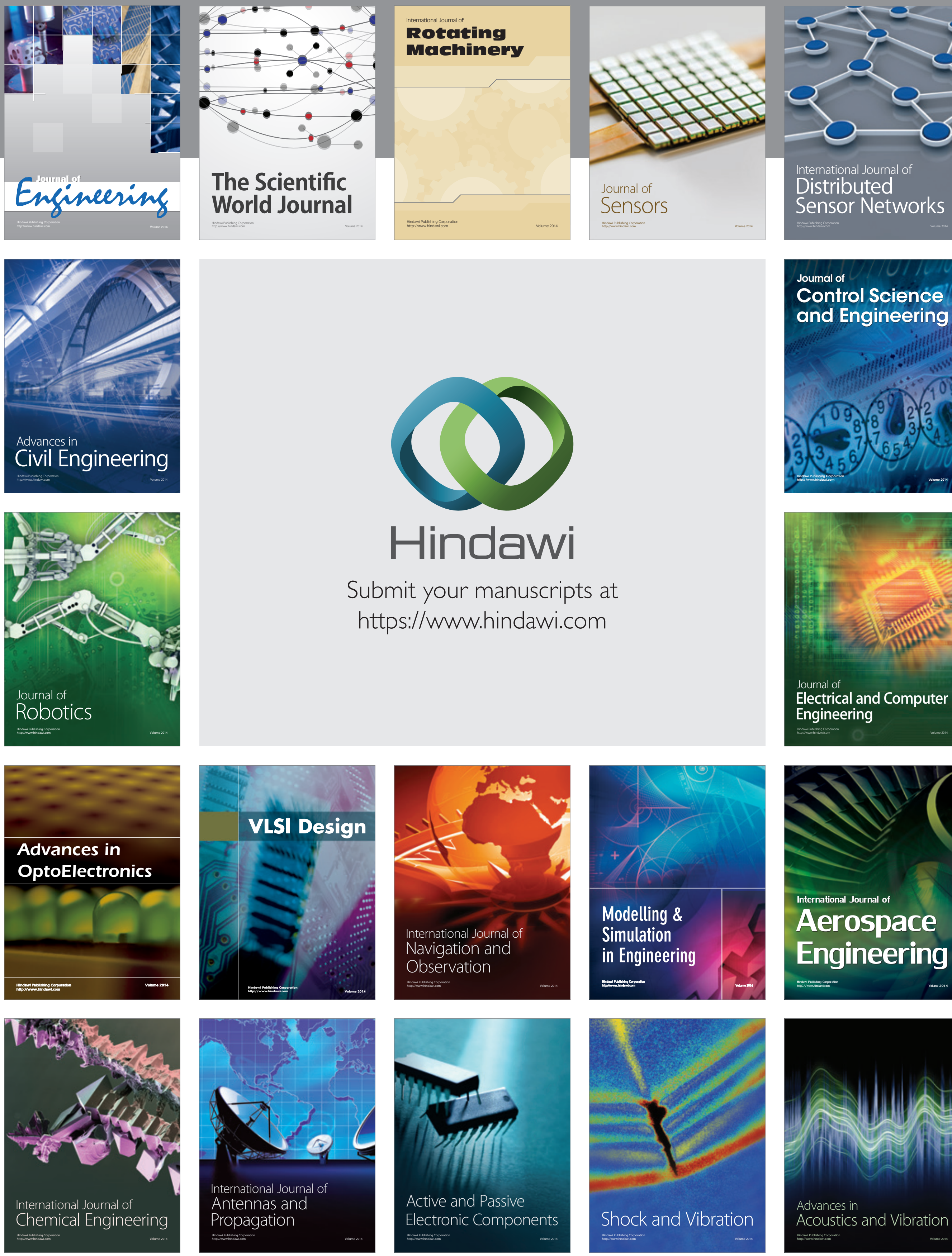
[15] C. H. Yoon and C. K. Un, "Performance of personal portable radio telephone systems with and without guard channels," *IEEE Journal on Selected Areas in Communications*, vol. 11, no. 6, pp. 911–917, 1993.

[16] M. M. Badawy and S. A. AlQahtani, "Adaptive joint call admission control for heterogeneous mobile networks," in *Proceedings of the World Congress on Engineering and Computer Science (WCECS '14)*, pp. 703–707, San Francisco, Calif, USA, October 2014.

[17] Y.-Y. Zhang, C. Xiao, and J. Wang, "An optimal joint call admission control policy in heterogeneous wireless networks," *International Journal of Future Generation Communication and Networking*, vol. 9, no. 1, pp. 207–222, 2016.

[18] J. Xie, J. Dang, C. Li, X. Lian, and J. Lin, "Ecology-inspired admission control scheme in heterogeneous wireless networks," in *Proceedings of the International Conference on Image, Vision and Computing*, pp. 140–144, Portsmouth, UK, August 2016.

[19] J. Martinez-Bauset, V. Pla, and E. Bernal-Mor, "Insensitive call admission control for wireless multiservice networks," *IEEE Communications Letters*, vol. 15, no. 9, pp. 989–991, 2011.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