Journal of Mobile Multimedia, Vol. 11, No. 3&4 (2015) 213–222

A SECURE-AWARE CALL ADMISSION CONTROL SCHEME FOR WIRELESS CELLULAR NETWORKS USING FUZZY LOGIC AND ITS PERFORMANCE EVALUATION

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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 research area. To support various integrated services with a certain Quality of Service (QoS) requirement Call Admission Control (CAC) is a good strategy. The CAC is one of the resource management functions, which regulates network access to ensure QoS provisioning. However, the decision for CAC is very challenging issue due to user mobility, limited radio spectrum, and multimedia traffic characteristics. In this paper, we propose a secure-aware CAC scheme for wireless cellular networks using fuzzy logic. For evaluation of proposed scheme, we implement a new simulator called Fuzzy CAC Simulator (FCACS). We evaluated by simulations the performance of proposed CAC scheme and show that the proposed scheme has a good behavior.

Keywords: Cellular Networks; CAC; Fuzzy Logic; Security.

1 Introduction

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 research area. To support various integrated services with a certain Quality of Service (QoS) requirement Call Admission Control (CAC) is a good strategy. The CAC is a provisioning strategy that limits the number of connections into the network in order to reduce the network congestion and call dropping.

In cellular wireless networks when the mobile node moves from one cell to another one, the bandwidth must be requested in the new cell. During this process, the call may not be able to get a channel in the new cell due to the limited resource, which will lead to the call dropping. Thus, the new and handoff calls have to be treated differently in terms of resource allocation.

Since users are much more sensitive to call dropping than to call blocking, the handoff calls are assigned higher priority than new calls [1, 2].

CAC techniques are required to guarantee QoS requirements for all traffic types. CAC is based on the knowledge of the statistical characteristics of ongoing and arriving calls. The decision to accept an additional call involves the calculation or estimation of the consequences of the call acceptance on blocking and delay of itself and other incoming calls.

Several schemes have been proposed for CAC in wireless cellular networks. However, during the complexity of CAC in wireless environment, many simplified models and assumptions are made. Some schemes consider that each mobile node will make hand-over to neighbouring cells with equal probability, which may be not accurate in general. For this reason, the intelligent and heuristic methods are needed.

Use of intelligent methods such as Fuzzy Logic (FL), Neural Networks (NN) or Genetic Algorithms (GA) can prove to be efficient for traffic control in telecommunication networks [3–20].

In [21–24], in order to deal with CAC in wireless cellular networks, we proposed a CAC scheme based on FL. We implemented and evaluated the proposed system by comparing its performance with Shadow Cluster Concept (SCC) [25]. In [26–28], we proposed a FL-based CAC scheme by considering priority of outgoing connections.

In this paper, we implement a Fuzzy Call Admission Control Simulator (FCACS). We present the quantitative evaluation results considering security parameter. The evaluation results show that the proposed scheme has a good behavior.

The structure of this paper is as following. In Section 2, we present our previous work. In Section 3, we explain our proposed FCACS. The simulation results are given in Section 4. Finally, we give conclusions and future work in Section 5.

2 Previous Work

2.1 SCC

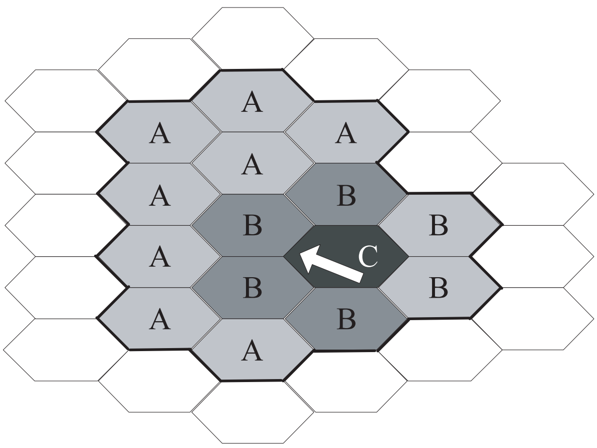


Fig. 1. SCC.

One of the previous work on CAC is SCC [25]. The fundamental idea of the SCC is that every mobile terminal with an active wireless connection exerts an influence upon the cells (and their BSs) in the vicinity of its current location and along its direction of travel. As an active mobile terminal travels to other cells, the region of influence also moves, following the active mobile terminal to its new location. The BSs (and their cells) currently being influenced are said to form a shadow cluster, because the region of influence follows the movements of the active mobile terminal like a shadow, as shown in Fig. 1.

The shadow is strongest near the active mobile terminal, and fades away depending on factors such as the distance to the mobile terminal, current call holding time and priority, bandwidth resources being used, and the mobile terminal's trajectory and velocity. Because of these factors, the shape of a shadow cluster is usually not circular and can change over time. The center of a shadow cluster is not the geometric center of the area described by the shadow, but the cell where the mobile terminal is currently located. This cell is considered as the mobile terminal's current home cell. A bordering neighbor is a cell that shares a common border with the shadow cluster's center cell.

Conceptually, the number and "darkness" of the shadows covering a cell reflect the amount of resources that the cell's BS needs to reserve in order to support the active mobile terminals currently in its own and in neighboring cells. With the information provided by shadow clusters, BSs can determine, for each new call request, whether the request can be supported by the wireless network. In practice, a shadow cluster is a virtual message system where BSs share probabilistic information with their neighbors on the likelihood that their active mobile terminals will move to neighbor cells (while remaining active) in the near future. With the information provided by shadow clusters, BSs project future demands and reserve resources accordingly. BSs reserve resources by denying network access to new call requests, and by "waiting" for active users to end their calls.

The decision process for the acceptance of a new call request also involves a shadow cluster. Every new call request results in the implementation of a tentative shadow cluster. BSs exchange information on their new call requests and decide, based on this and other information, which requests should be accepted and which requests should be denied.

2.2 FL-based CAC

In our previous work, in order to deal with CAC in wireless cellular networks, we proposed a CAC scheme based on FL [21–24]. Conventional CAC schemes for wireless networks must consider some measured parameters to make the decision. However, in wireless networks due to user mobility and varying of channel condition the measurement obtained are not accurate. Also, it is very difficult to obtain the complete statistics of the input traffic. Therefore, the CAC decision must be made based on the uncertain or inaccurate information. This is why we use FL. We implemented and evaluated the proposed system by comparing its performance with Shadow Cluster Concept (SCC) [25]. We showed that the proposed scheme could achieve a better prediction of the user behavior and a good admission decision compared with SCC.

3 Proposed System

3.1 Proposed FCACS

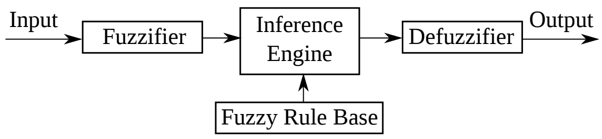


Fig. 2. FLC structure.

Table 1. Fuzzy Rule Base.

Rule No.	Ump	Rc	Sc	A/R
1	B	S	Lo	R
2	B	S	Mi	R
3	B	S	Hi	WR
4	B	M	Lo	R
5	B	M	Mi	WR
6	B	M	Hi	WA
7	B	L	Lo	NRNA
8	B	L	Mi	WA
9	B	L	Hi	A
10	N	S	Lo	R
11	N	S	Mi	WR
12	N	S	Hi	NRNA
13	N	M	Lo	WR
14	N	M	Mi	NRNA
15	N	M	Hi	WA
16	N	L	Lo	WA
17	N	L	Mi	A
18	N	L	Hi	A
19	G	S	Lo	R
20	G	S	Mi	NRNA
21	G	S	Hi	WA
22	G	M	Lo	NRNA
23	G	M	Mi	WA
24	G	M	Hi	A
25	G	L	Lo	WA
26	G	L	Mi	A
27	G	L	Hi	A

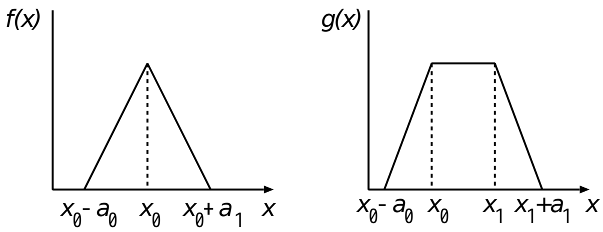


Fig. 3. Membership function.

The Fuzzy Logic Controller (FLC) is the main part of the proposed Fuzzy Call Admission Control Simulator (FCACS) and its basic elements are shown in Fig. 2. They are the fuzzifier, inference engine, Fuzzy Rule Base (FRB) and defuzzifier. As membership functions, we use triangular and trapezoidal membership functions because they are suitable for real-time operation [29]. The membership functions are shown in Fig. 3.

The structure of proposed FCACS is shown in Fig. 4. The input parameters for FCACS are: User movement prediction (*Ump*), user Security (*Sc*) and the Remain capacity (*Rc*) of a base-station. The Real Time Counter (*RTC*) and Non Real Time Counter (*NRTC*) are used for bandwidth management. While, the output linguistic parameter is the Accept/Reject decision (*A/R*).

The term sets of *Ump*, *Sc* and *Rc* are defined as:

$$\mu(Ump) = \{Bad, Normal, Good\} = \{B, N, G\};$$
$$\mu(Sc) = \{Low, Middle, High\} = \{Lo, Mi, Hi\};$$

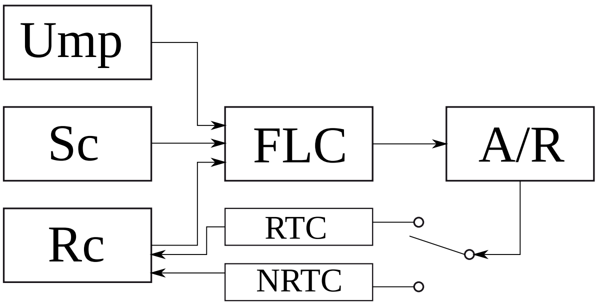


Fig. 4. Proposed FCACS.

$$\mu(Rc) \quad = \quad \{Small, Middle, Large\} = \{S, M, L\}.$$

In order to have a soft admission decision, for the output linguistic parameter (A/R), we considered not only "accept" and "reject" but also "weak accept", "weak reject", and "not accept not reject" for the accept/reject decision. The membership functions for input and output linguistic parameters of FCACS are shown in Fig. 5. The Fuzzy Rule Base (FRB) shown in Table 1 has 27 rules.

The membership functions for input parameters of the FCACS are defined as follows:

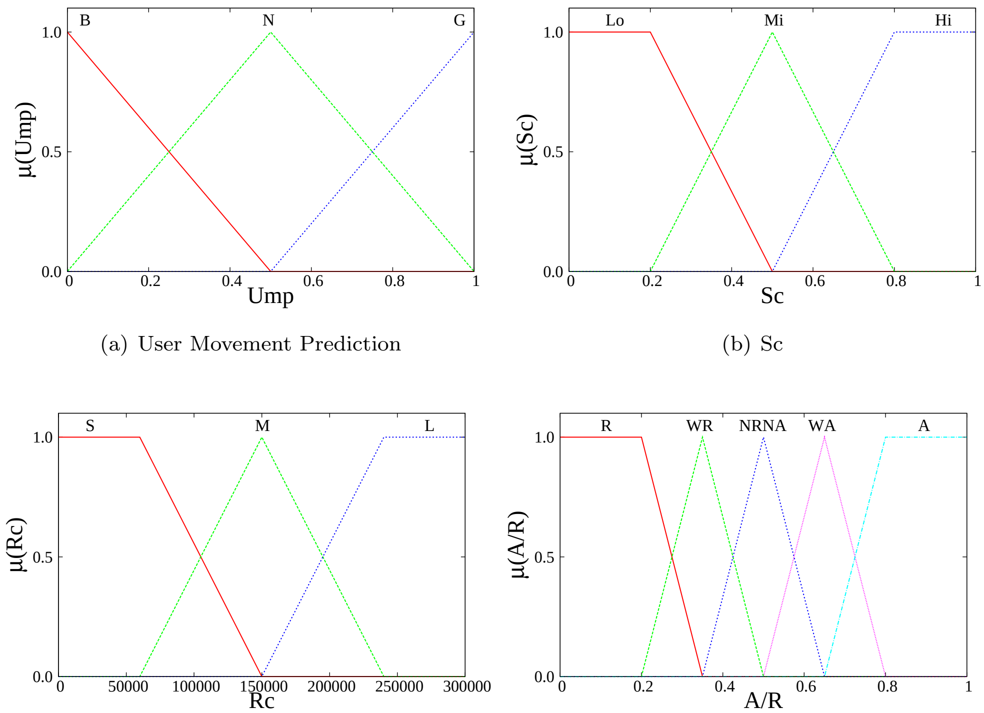
$$\begin{aligned}
\mu_B(Ump) &= f(Ump; B_0, B_{w0}, B_{w1}); \\
\mu_N(Ump) &= f(Ump; N_0, N_{w0}, N_{w1}); \\
\mu_G(Ump) &= f(Ump, G_0, G_{w0}, G_{w1}); \\
\mu_{Lo}(Sc) &= g(Sc; Lo_0, Lo_1, Lo_{w0}, Lo_{w1}); \\
\mu_{Mi}(Sc) &= f(Sc; Mi_0, Mi_{w0}, Mi_{w1}); \\
\mu_{Hi}(Sc) &= g(Sc; Hi_0, Hi_1, Hi_{w0}, Hi_{w1}); \\
\mu_S(Rc) &= g(Rc; S_0, S_1, S_{w0}, S_{w1}); \\
\mu_M(Rc) &= f(Rc; M_0, M_{w0}, M_{w1}); \\
\mu_L(Rc) &= g(Rc; L_0, L_1, L_{w0}, L_{w1}).
\end{aligned}$$

The term set of the output linguistic parameter $\mu(A/R)$ is defined as

$$\mu(A/R) = \begin{pmatrix} Reject \\ WeakReject \\ NotRejectNotAccept \\ WeakAcceptr \\ Accept \end{pmatrix} = \begin{pmatrix} R \\ WR \\ NRNA \\ WA \\ A \end{pmatrix}.$$

The membership functions for the output parameter A/R are defined as follows:

$$\begin{aligned}
\mu_R(A/R) &= g(A/R; R_0, R_1, R_{w0}, R_{w1}); \\
\mu_{WR}(A/R) &= f(A/R; WR_0, WR_{w0}, WR_{w1}); \\
\mu_{NRNA}(A/R) &= f(A/R; NRNA_0, NRNA_{w0}, NRNA_{w1}); \\
\mu_{WA}(A/R) &= f(A/R; WA_0, WA_{w0}, WA_{w1}); \\
\mu_A(A/R) &= g(A/R; A_0, A_1, A_{w0}, A_{w1}).
\end{aligned}$$



(a) User Movement Prediction

(b) Sc

(c) Remain Capacity

(d) Accept/Reject

Fig. 5. FCACS membership functions.

4 Simulation Results

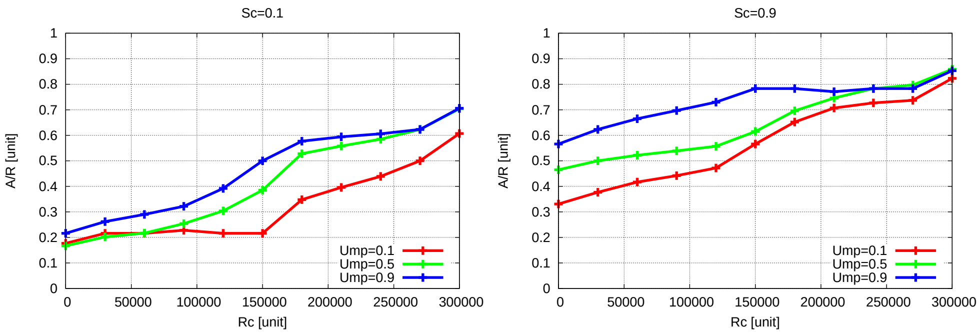
The simulation were carried out in Linux Cent OS 6.6 computer. The simulation parameters are shown in Table 2.

In Fig. 6 and Fig. 7, we show the A/R unit values vs. Rc when Sc and Ump are considered as constant parameters, respectively. The simulation results show that with increasing of the remain capacity of the base station, the A/R is increased. Also, with increasing of Sc and Ump, the A/R is increased.

Then, we consider Sc and Ump as probabilistic parameters. If the remain capacity of the base station is less than the content size of the request, connection request can not be accepted. We consider the capacity of the base-station is 300000 units.

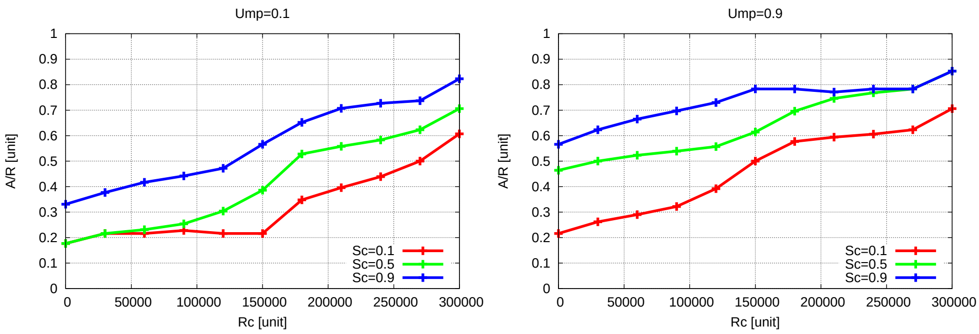
We conducted simulations 5000 times in order to get general view of results. We generate Ump and Sc values randomly from 1 to 100 and from 0 to 1, respectively.

In Fig. 8 and Fig. 9, the acceptance rate increases with the increase of the Rc. In Fig. 8, when the Ump is "good", the acceptance rate is increased faster comparing when the Ump is "bad". In Fig. 9, when the Sc is "high", more connection requests are accepted compared with the case when Sc is "low". The Rc parameter has strong effect compared with the other input parameters. The acceptance rate rapidly increases when the level of the Rc is increased.



(a) Sc=0.1 (b) Sc=0.9

Fig. 6. A/R vs. Rc for different Ump values when Sc is a constant parameter.



(a) Ump=0.1 (b) Ump=0.9

Fig. 7. A/R vs. Rc for different Sc values when Ump is a constant parameter.

5 Conclusions

In this paper, we presented a secure-aware CAC scheme for wireless cellular networks. The simulation were carried out using FCACS. From the simulation results, we conclude as following.

- When Sc and Ump parameters are increased, the A/R value increases.
- When the Ump is "good", the acceptance rate is increased faster comparing when Ump is "bad".
- When the Sc is "high", more connection requests are accepted compared with the case when Sc is "low".
- The acceptance rate rapidly increases when Rc is increased.

In the future, we would like to evaluate the proposed system by extensive simulations.

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Table 2. Simulation parameters.

Parameters	Values
Capacity of the base station	300000
Simulation time	2000
Number of simulations	5000
Contents percentage (text, voice, movie)	Uniform
Contents size (text, voice, movie)	$300, 5, 300$
Number of requests per second	Uniformly from 1 to 230
Connection keeping time (text)	1
Connection keeping time (voice)	Normally ($\mu = 50.0$, $\sigma = 3.0$) Min: 1.0, Max: 100.0
Connection keeping time (movie)	Normally ($\mu = 100.0$, $\sigma = 3.0$) Min: 10.0, Max: 300.0
User movement prediction	Uniformly from 1 to 100
Security value	Normally ($\mu = 0.5$, $\sigma = 3.0$) Min: 0.0, Max: 1.0

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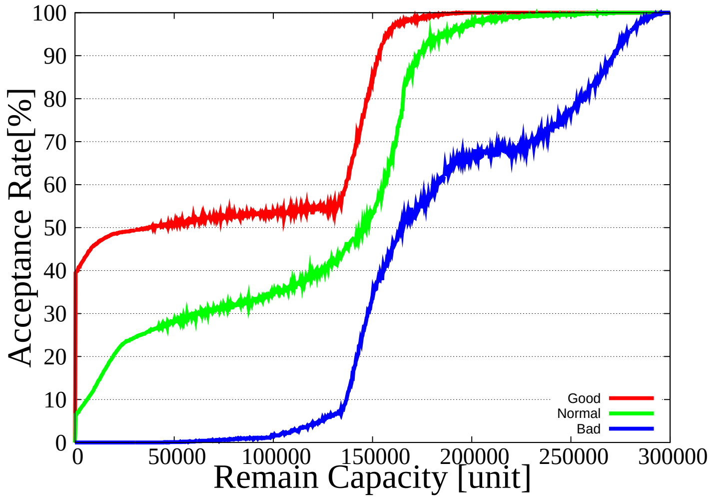

Fig. 8. Acceptance rate vs. Rc for different Ump values.

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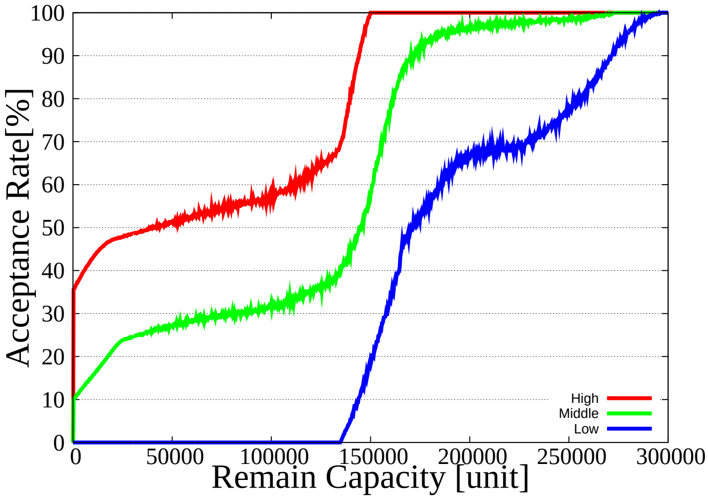

Fig. 9. Acceptance rate vs. Rc for different Sc values.

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