The International Journal of Soft Computing and Software Engineering [JSCSE], Vol. 3, No. 3, Special Issue:
The Proceeding of International Conference on Soft Computing and Software Engineering 2013 [SCSE'13],
San Francisco State University, CA, U.S.A., March 2013
Doi: 10.7321/jscse.v3.n3.105 e-ISSN: 2251-7545

A Soft Computing System for Resource Management of Femtocell Networks

Sami S Alwakeel
Computer Engineering Department
King Saud University
Riyadh, kingdom of Saudi Arabia
swakeel@ ksu.edu.sa

Muhammad Ammad-uddin
Sensor Networks & Cellular System Research Center
University of Tabuk
Tabuk, Kingdom of Saudi Arabia
mohammad.ammad@gmail.com

Abstract—**Femtocell is a small cellular base station, typically designed for use in a home or small business. With a Public access to Femtocell system, a large number of public users will migrate to the Femtocell network, whenever they enter the Femtocell coverage area. As a result, the Femtocell will be severely congested, and its home users will suffer from performance degradation. In this study, we propose a soft computing system forcall admission in Femtocell networks. The system allows public call to be accepted only if it does not degrade the performance of Femtocell indoor home calls. The system constitutes of both resource partition policy and a call admission algorithm for dynamic resource management of Femtocell network. The partition based control policy allows Femtocell resource partition and prioritizes its calls as: Femtocell voice calls, Femtocell data calls, Handover public voice calls, Handover public data calls, New public voice calls, and New public data calls respectively. The Call Admission Control (CAC) algorithm is implemented for optimization of the calls admission to the Femtocell network partitions. We tested this policy with the combination of six different CAC algorithms 1- Open Access (OA), 2- Restricted Access (RA), 3- Open Shared Access (OSA), 4-Probabilistic Shared Access (PSA), 5-Probabilistic Access (PA) and 6-Bayesian based dynamic probability Access (BDP). The performance results of these algorithms are compared. The research results shows that our proposed soft computing based system for dynamic management of Femtocell resources improves network efficiency and throughput.**

Keywords- Soft computing based Femtocell resource management, Femtocell Call admission control, Femtocell Quality of service, Bayesian based Femtocell access control

I. INTRODUCTION

Femtocell is a small cellular base station, typically designed for use in a home or small business offices[1]. Typically all end users are connected wirelessly with a small Femtocell device installed inside the building and then it connects to the service provider's network via broadband connection(such as DSL or cable)as shown in Figure-1.Femtocelltechnologies are gettingmore popular as itreducesthe capital and operational cost of mobile service providers while enhancingtheir system coverage and capacity. Currently,Femtocell is included in Third Generation Project [2] (3GPP) in its 8th release. Femtocell also got full support in Universal Mobile Telecommunications System (UMTS)andLong Term Evolution (LTE) standards.

Femtocell is different from UMA (Unlicensed Mobile Access) (UMA), as it uses operator's licensed or leased UMT/LTE spectrum[3]instead of UMA Wi-Fi 2.5 GHz unlicensed frequency band which can cause service degradation or poor quality of service due to interference from many other free communication devices in the Wi-Fi band.

According to a study[3]50% of all voice calls and more than 70% of data traffic originates indoors. Thus,it's more feasible to install an indoor Femtocell unit to incorporate this traffic by using IP backbone rather than utilizing a macro cellular base station (BS) tower. The owner of femtocell will have better quality of service in terms of throughput of voice and data calls. On the other side, a passing customer nearFemtocell coverage area can also get the benefit of this service. We can distinguishFemtocell calls based on its subscription, bandwidth and connectivity age as shown in Figure-2.

The International Journal of Soft Computing and Software Engineering [JSCSE], Vol. 3, No. 3, Special Issue:
The Proceeding of International Conference on Soft Computing and Software Engineering 2013 [SCSE'13],
San Francisco State University, CA, U.S.A., March 2013
Doi: 10.7321/jscse.v3.n3.105 e-ISSN: 2251-7545

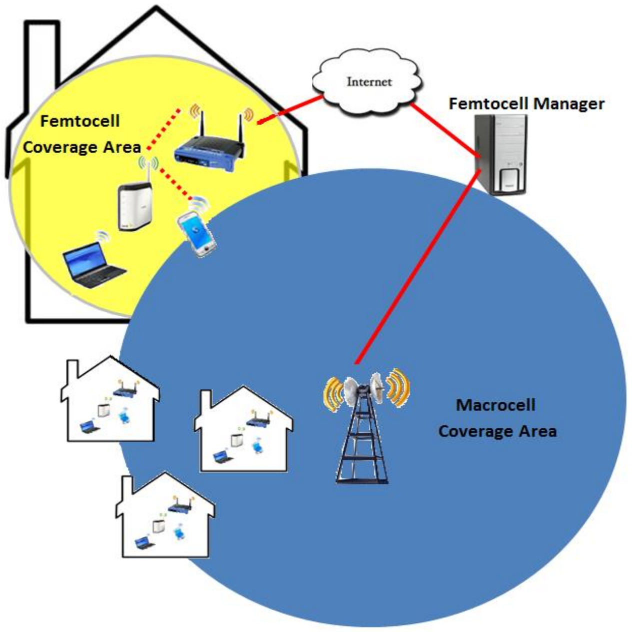


Figure 1: Femtocell Architecture

A. Femtocell callsvs Puplic Calls

Based on subscription, calls may come from a Femtocell subscriber/owner. Subscriber's call should always have priority over other calls.Public calls mean callsthat are generated by a non-subscriber orfrom other cellularnetwork customers. Those are users accessing the Femtocell services when passing by its coverage area. Public call can only be admitted if they do not degrade the femtocell quality of service for the owner.According to 3-GPP release-9 standard, asubscribercan register himself as owner of the Femtocell or for a group ofFemtocells.

B. Voice calls vs Data calls:

According to bandwidth, calls may be considered as Voice calls or Data calls. Voice call needs very low bandwidth about 10 kbps while data call requires much higher signal quality and more bandwidth and resides on the system for longer time then voice calls.

C. New calls vs Handover calls:

According to connectivity age, Femtocellincoming calls can be distinguished as new calls or hand over calls. A new call is a call which seeks connectivity to the network, while handover calls are those calls which are already connected but require change of its connection status.

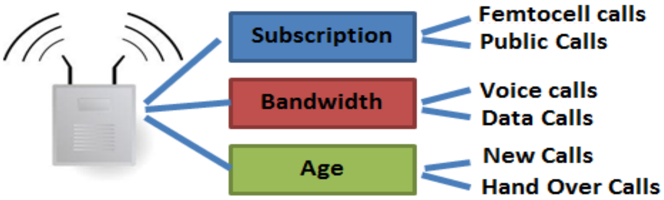
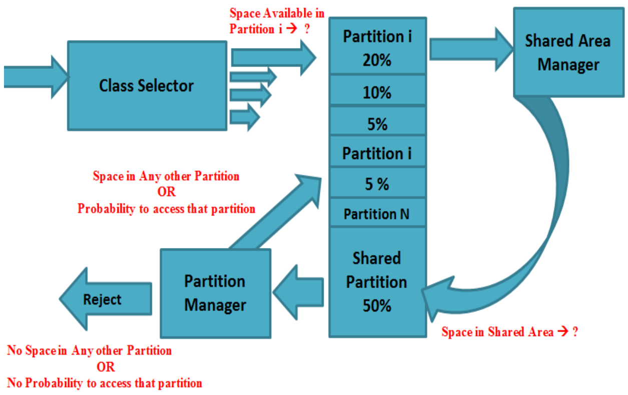


Figure 2: Calls Classification

Accordingly, Femtocell calls may be categorizedinto six categories based on its status being voice or data, Femtocell or public, new or handover calls. These are:



1. Femtocell voice calls
2. Femtocell data calls
3. Handover public voice calls
4. Handover public data calls
5. New public voice calls
6. New public data calls

Arecently active research area is to study how to develop a call admission policy to control these various calls accessto the Femtocell. This policy is necessary to manage the amount of traffic transmitted on the backhaul (i.e., between the Femtocell and cellular operator) and to regulate the air interface capacity used by Femtocell subscribers and non-subscribers.In[4], a Co-channel Femtocell access control method was proposed.Research studies in references[5], [6], [7] and [8]proposed two CAC algorithms namely: open access and close access. A hybrid of both are proposed in [9],[10] and [11]. The comparison of different CAC algorithms (Dedicated channel vs. co-channel, Open access vs. closed subscriber group (CSG), and Fixed downlink transmit power vs. adaptive downlink transmit Power) are conducted in [12] and it is concluded that co-channel operation algorithm performs better. Probabilistic CAC policy is given in [13]. Other proposed access control methods for Femtocell system are investigated in [14], [15]and[16]. All these previous studies indicated theneed of dynamic CAC control algorithm to exploits the call uncertainty, and process imprecise informationforoptimized Femtocell resources management. In this study, we introduce a new soft computing based CAC policy for resource management of Femtocell system.

The rest of paper is organized as follows: section 2 describes the proposed CAC policy and its variations/combinations. The analytic model used for performance measures are given in Section 3. Simulation model is shown in section 4 and analysis of output data is conducted in section 5. Finally concluding remarks are presented in section 6.

The International Journal of Soft Computing and Software Engineering [JSCSE], Vol. 3, No. 3, Special Issue:
The Proceeding of International Conference on Soft Computing and Software Engineering 2013 [SCSE'13],
San Francisco State University, CA, U.S.A., March 2013
Doi: 10.7321/jscse.v3.n3.105 e-ISSN: 2251-7545

II. PROPOSED SYSTEM

Upon giving public access to Femtocellsystem, a large number of Macro cell users are expected to migrate to the underlying Femtocell system which can severely degrade the service quality. A Call Admission Control (CAC) algorithm is required for restricting some calls to maintain quality of service for indoor users. The soft computing based system constitutes of both resource partition policy and a dynamic resource management of the Femtocell network. Femtocellbandwidth resource are divided into seven partitions, one partition is reserved for each type of calls and the seventh partition is classified as a common shared bandwidth resource for all calls types. Similar to [17]our assumption is that the Macro cell operator will lease some bandwidth resource to a Femtocell operator, in order to get more coverage, better QoS and more user satisfaction. To admit a call for a partition, we used variants of the basic close access policy that only allow Femtocell subscribers to connect to it.This result the following six call admission control algorithms:

1. Restricted access
2. Open Access
3. Open Shared Access
4. Probabilistic Shared Access
5. Probabilistic Access
6. Dynamic Probability Content Aware Bayesian Access

The block diagram for proposed call admission policy is shown in Figure-3 and discussed in what follows:

Figure 3: Admission control policy Block diagram

Considering these access modes for Femtocell system, whenever a call comes, it is accepted in its corresponding partitions, if no space available in that partition, the system tries to accommodate this request in the common shared partition according to a given probability. If no shared space is available, ordue non occurring persistent probability event the accessto shared partition is denied, the request will be accepted in any other attainable under-utilized partition but with a dynamic probability, calculated byBayesian formula.

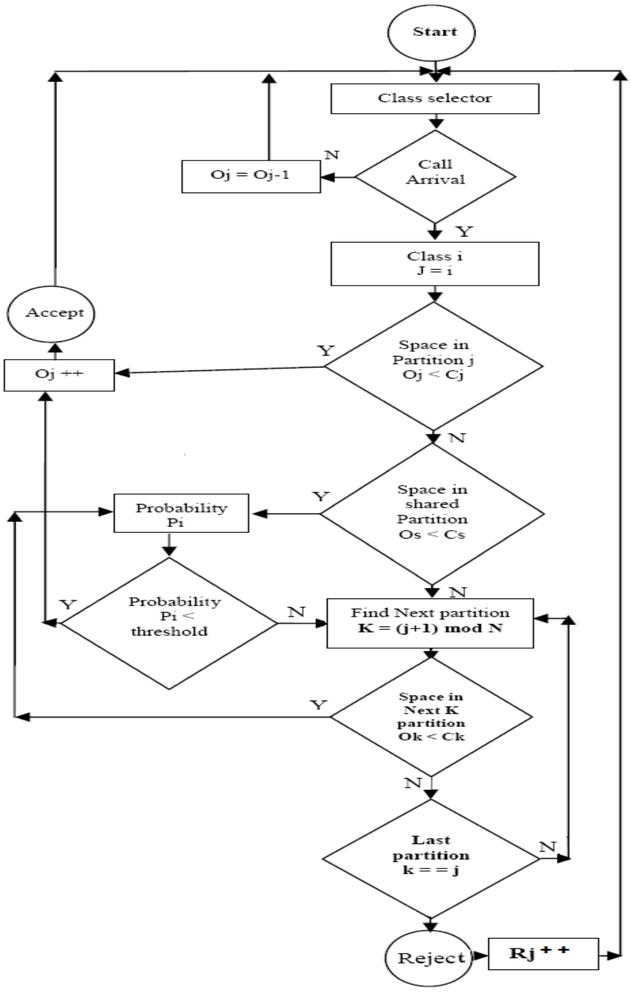
Accordingly we have N classes of calls (N = 6) and every call Class have different arrival rate **λi**where***(i =1 to 6).*** We divide the total Femtocellbandwidth resource capacity **(C)** of femtocell server into ***M*** partitions as shown in Figure-3***M = N+1*** (Each partition corresponding to one Class plus the shared)

Figure 4: Flow chart of proposed system

Some percentage of the total resource capacity is reserved as shared capacity ***Cs*** to accommodate any Class of call.

Each partition is assigned a capacity ***Cj (j = 1 to M) and***

$$C = \sum_{j=1}^{m} Cj = 100\ \%$$



When a request arrives for Class ***i***, it first checks its corresponding partition ***j (j=i).*** If space is available in partition ***j*** it will be accepted and the occupancy of partition ***j*** is incremented

Oj = Oj+BWij (***Ojis*** occupancy of partition ***j)***

(***BWij*** is the requested bandwidth of class request ***i***, % of Partition **Cj**)

If no space in corresponding partition ***(Oj = Cj)***then a check is made to the shared partition ***Cs,*** The call is then admitted to the shared space according to probability***Pis***where:

Pis is probability to access the shared partition **S** for the Class call***i***

If no probability or no space in shared partition then call will be admitted in any other partition with ***Pij*** probability where:

Pij is probability to access the ***j*** partition for ***i*** Class call)
This process is then repeated using modules sum

The International Journal of Soft Computing and Software Engineering [JSCSE], Vol. 3, No. 3, Special Issue:
The Proceeding of International Conference on Soft Computing and Software Engineering 2013 [SCSE'13],
San Francisco State University, CA, U.S.A., March 2013
Doi: 10.7321/jscse.v3.n3.105 e-ISSN: 2251-7545

$$j = (i+1) \bmod N$$

Until all partitions is checked***(i .e j == i)***

If no admission is achieved, then call Class ***i*** then rejected ***(Ri = Ri+1).*** If any call leaves the partition ***j*** system then the occupancy is decremented (***Oj = Oj - BWij)***

The proposed system is examined with six different variants CAC algorithms as described next.

A. Open access (OA)

Open access mean Open for all[18]. Any call will be accepted if capacity availablein any partition. The probabilitymatrix of admission isshown in Table-1

TABLE1 OPEN ACCESS

P i j = Call category	Partitions: *1*	*2*	*3*	*4*	*5*	*6*	*M*
1	100	100	100	100	100	100	100
2	100	100	100	100	100	100	100
3	100	100	100	100	100	100	100
4	100	100	100	100	100	100	100
5	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100

B. Partition Restricted Access (PRA)

As described in[5], basic close access policy allowsonly Femtocellsubscribers to connect it.Partition restricted access policy is a relaxed closenessin the sense that it allocates fixed bandwidth for each type of call, and any call request can only be admitted in its corresponding partition.If no space is available in corresponding partition, then call request will be rejected. As shown in Table-2 all call categories have 100 percent probability to access its own assigned partition but not allowedto access any other partition.

TABLE 2 PARTITION RESTRICTED ACCESS

P i j = Call category	Partitions: *1*	*2*	*3*	*4*	*5*	*6*
1	100	0	0	0	0	0
2	0	100	0	0	0	0
3	0	0	100	0	0	0
4	0	0	0	100	0	0
5	0	0	0	0	100	0
6	0	0	0	0	0	100

For this policy, no separate resources are allocated for common.

C. Open Shared Access(OSA)

As shown in Table-3 a request will be admitted either in its corresponding partition or in shared partition if space is available in any one of them. All types of calls will be given equal probability to get admitted in the shared area but it is not allowed to access any other partition.

TABLE3 OPEN SHARED ACCESS

P i j = Call category	Partitions: **1**	**2**	**3**	**4**	**5**	**6**	**M**
1	100	0	0	0	0	0	100
2	0	100	0	0	0	0	100
3	0	0	100	0	0	0	100
4	0	0	0	100	0	0	100
5	0	0	0	0	100	0	100
6	0	0	0	0	0	100	100

D. Probabilistic Shared Access(PSA)

Any call will be admitted according to the availability of space in its own partition or in shared partition. High priority calls will have better probability to access shared partition. Similarto previous algorithmno call is allowed to access any other partitions.PSA probability matrix is shown in Table-4.

TABLE 4 PROBABILISTIC SHARED ACCESS

P i j = Call category	Partitions: *1*	*2*	*3*	*4*	*5*	*6*	*M*
1	100	0	0	0	0	0	100
2	0	100	0	0	0	0	90
3	0	0	100	0	0	0	80
4	0	0	0	100	0	0	70
5	0	0	0	0	100	0	60
6	0	0	0	0	0	100	50

E. Static Probabilistic Access(SPA)

A call will be admitted in either in its own partitions if space is available or in any attainable partition, including shared partition according to a given probability. Higher priority class requests will have higher probability to get admitted in shared partition and in lower class partition. SPA probability matrix isshown in Table-5.

TABLE 5 STATIC PROBABILISTIC ACCESS

P i j = Call category	Partitions: *1*	*2*	*3*	*4*	*5*	*6*	*M*
1	100	100	100	100	100	100	90
2	50	100	100	100	100	100	80
3	30	60	100	100	100	100	60
4	20	40	60	100	100	100	50
5	20	40	60	80	100	100	40
6	20	40	50	60	80	10	30

F. Bayesin based Dynamic probabilityAccess (BDP)

A call will be admitted in its corresponding partition otherwise the system will decide which partition is appropriate to admit

Doi: 10.7321/jscse.v3.n3.105 e-ISSN: 2251-7545

this request. This decision depends upon accumulated values of all the attributes of the incoming call and the system at the time the call request arrives. Some of the major attributes are as:

Priority of Incoming call: high priority call needs better likelihood to be accepted (e.g. Femtocell owner's call request should never be rejected)

Occupancy of each partition: Whenever a partition goes under-utilized, then we need to accept most of the calls in that partition.

Time slot of call: if call request comes on busy/ peak hours, admission criteria will be stricter as the system is expecting high arrival rate of incoming calls.

Average call duration: Data calls reserve the resources for a longer time as compare to voice calls.

Assigned capacity: The call class which utilizes more resources will get lower probability to access other partitions.

Partition allowance: any call request will get more likelihood to get admitted in lower class partition and lower chance to get admitted in a higher priority call partition.

Our proposed soft computing system will take the best decision depends upon above dynamic attributes to decide wither this request to be admitted or not. Furthermore, if it can be admitted, the system decides which partition is more suitable.

The dynamic probability to access any partition is calculated by Bayesian classifier. When a call of category ***i*** arrives it will be accommodated in partition ***i*** if space available, otherwise it will accommodated in shared partition area or any other partition depending upon the content aware Bayesian dynamic probability ***Pij*** which is shown in equation (1).

$$Pij = \frac{Pij = \prod_{K-1}^{n} Source(K)}{\prod_{K=1}^{n} Source(K) + \prod_{K=1}^{n}(1 - Source(K))} \quad (1)$$

Pij = probability to access the **j** partition for ***i*** Class call
K = Index of score (1 to 7) representing partition j
To calculate the Bayesian probability, every attribute is classified into a groupwhich is assigned a weight/value depending upon its importance. The Probability is calculated dynamically depending upon the attributes types and their values given in Table-6.

TABLE 6: CALL AND SYSTEM ATTRIBUTES FOR BAYESIAN PROBABILITY

Attrib.	1	2	3	4	5	6	7
Call Class	Cat-1 1	Cat-2 0.8	Cat-3 0.6	Cat-4 0.5	Cat-5 0.4	Cat-6 0.3	
Partition allowance	Partition 1 0.5	Partition 2 0.6	Partition 3 0.7	Partition 4 0.8	Partition 5 0.9	Partition 6 0.95	Shared 1
Time of request	Late night 1	Normal Hours0.6	Peak Hours 0.4				
Average duration of call	< 2min 1	>2<4 min 0.8	>4<8 0.6	>8<10 0.5	>10 0.4		
Assigned capacity	Large 1	Medium 0.8	Small 0.6	Very small 0.4			
Occupancy of assigned partition	<50 1	>50<60 0.8	>60<70 0.6	>70<80 0.5	>80 0.4	100	

III. PERFORMANCE MEASURE

Here we present the performance measures used for the system evaluation. As explained before, incoming requests are classified into six categories **(i=1 to 6)** and Femtocellbandwidth resources are divided into seven partitions, one partition for each class request plus one extra partition used as common shared. Let Arrival rate of each category of class traffic is λ***i*** and Capacity of each partition is: ***Cj our*** performance measures are given by the following equations:

j = 1 to 7 (C7= shared partition), Then:

$$Ai = \frac{Total\ admitted\ class\ i\ X\ 100}{Total\ arrival\ of\ class\ i} \quad (2)$$

Percentage of admitted request all classes:

$$AT = \frac{Total\ admitted\ of\ all\ classes\ X\ 100}{Total\ arrival\ of\ all\ class} \quad (3)$$

Avg. Occupancy of partition j

$$Oj = \frac{\sum_{L=1}^{Number\ of\ call\ admited} \text{OLX duration of acupancy OL}}{Total\ Simulation\ time} \quad (4)$$

Avg. Occupancy of system (all partition)

$$OT = \frac{\sum_{i=1}^{M} \sum_{L=1}^{number\ of\ call\ admited} OLX \text{ duration of acupancy } OL}{Total\ Simulation\ time} \quad (5)$$

The International Journal of Soft Computing and Software Engineering [JSCSE], Vol. 3, No. 3, Special Issue:
The Proceeding of International Conference on Soft Computing and Software Engineering 2013 [SCSE'13],
San Francisco State University, CA, U.S.A., March 2013
Doi: 10.7321/jscse.v3.n3.105 e-ISSN: 2251-7545

This performance measure of our system is evaluated by above equations and is presented in Figure 5 to 10.

IV. SIMULATION MODEL

Simulation of the proposed system is conducted in OMNeT++, where the proposed CAC algorithmis tested in combination with six distinctive variants of CAC (Restricted access, Open Access, Open Shared Access, Probabilistic Shared Access, Probabilistic Access and Dynamic probability). All these CAC policies are tested with variable input parameterssuch as: Call arrival rate of each individual class, callpartition occupancy, call resident time, etc. Every simulation trial is executed several times, and the average results are collected.

V. RESULT ANALYSIS

Based on Equation (2) percentages of acceptance of Femtocell Voice and Femtocell data calls are shown in Figure-5 and 6 respectively. Percentage of acceptance of all types of class requests simulated by Equation (3) is shown in Figure-7. Based on Equation (4) occupancy of femtocell voice and femtocell data partition is shown in Figure-8 and 9 and occupancy of the overall system (all partitions) is shown in Figure-10. The proposed CAC algorithms are examined with a varying load (number of incoming call requests per unit time), and performances of all algorithms are tested with normal to heavy load conditions. The abbreviations used in all figures are shown below.

Abbreviation	Meaning
F	Femtocell
D	Data
V	Voice
P1	partition 1
P2	partition 2
U	Utilization
1,2,3,4,5,6	CAC case 1 to CAC Case 6

As shown in Figure-5. It is very clear that Femtocell voice calls (the calls come from the owner of the Femtocell) are never degraded in performance with BDP algorithm. Figure-6Shows the acceptance rate of Femtocell data calls which are similar to Figure-5. The overall performance of the system is shown in Fig-7. As shown, if we are concerned about the QoS for Femtocell Owner's calls, then BDP is the best choice. If however we need an overall efficient system performance, then SPA is the optimum.

Comparison of BDP Algorithm utilization with other proposed and conventional algorithms is shown in Figure-8, 9, and 10.

From these figures it is clear that a major advantage of our proposed system is that we can tune/optimize the system as needed by adjusting the input parameters values given in Tables 1 to 5 shown before. By adjusting the values of dynamic attributes shown in Table-6, the service provider can get a higher acceptance rate as these attributes have a strong impact and are critical for the system performance.

VI. CONCLUSION

In this study, we proposed a new concept of soft computing based admission control and resource management system for Femtocell system. We tested this newly proposed system with combination of different CAC algorithms (open access and restricted access) and some newly proposed CAC policies (Open Shared Access, Probabilistic Shared Access, Probabilistic Access and Dynamic probability). We found that implementing a soft computing resource management in combination with Bayesian based content aware CAC policy out performs many other traditional CAC algorithms used in Femtocell networks.

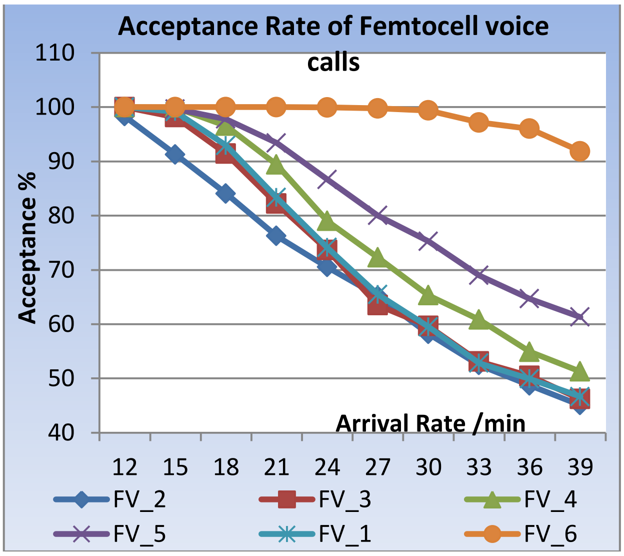


Figure 5: Acceptance rate of Femtocell voice calls

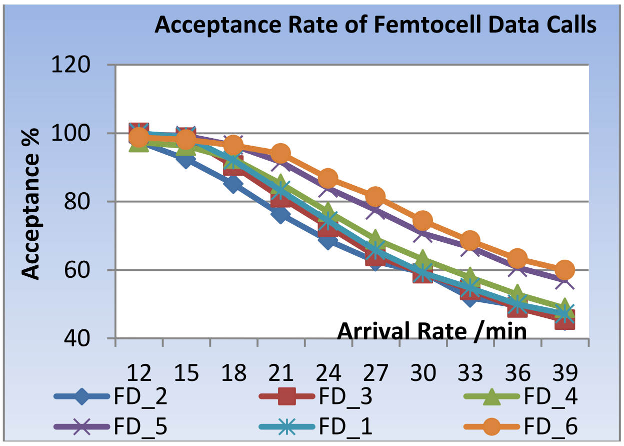


Figure 6: Acceptance rate of Femtocell Data calls

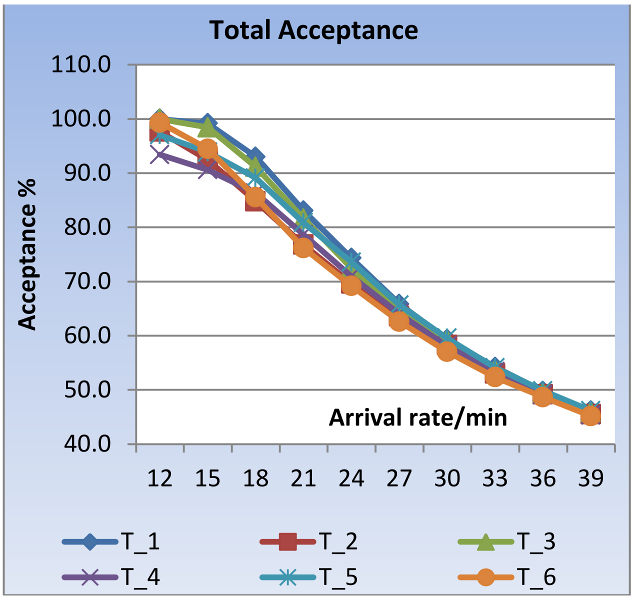


Figure 7: Comparison of all proposedalgorithms

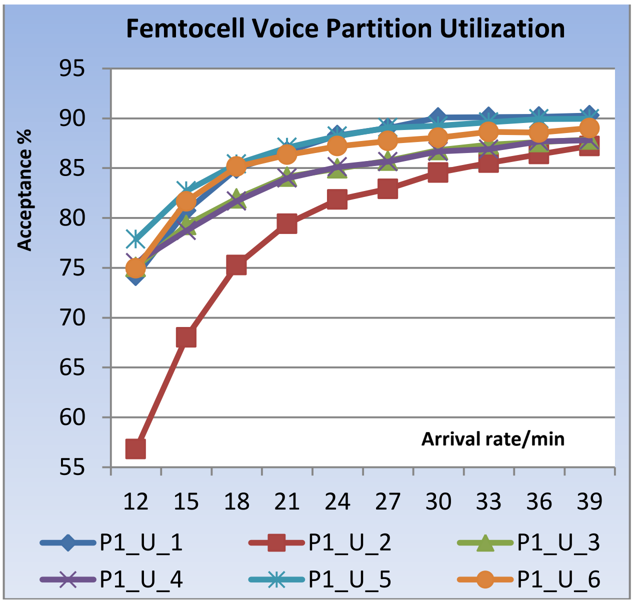


Figure 8: Femtocell Voice Partition Utilization

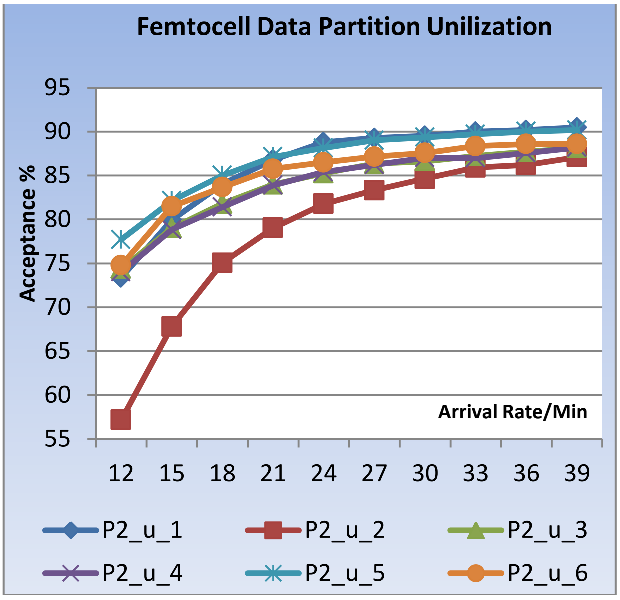


Figure 9: Femtocell Data Partition utilization

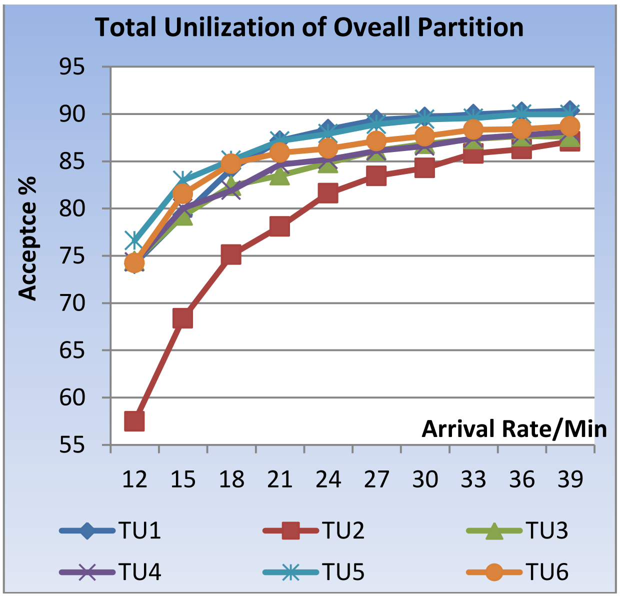


Figure 10: Total Utilization

The International Journal of Soft Computing and Software Engineering [JSCSE], Vol. 3, No. 3, Special Issue:
The Proceeding of International Conference on Soft Computing and Software Engineering 2013 [SCSE'13],
San Francisco State University, CA, U.S.A., March 2013
Doi: 10.7321/jscse.v3.n3.105 e-ISSN: 2251-7545

REFERENCES

[1] "wikipedia." [Online]. Available: http://en.wikipedia.org. [Accessed: 12-Mar-2012].
[2] "3GPP." [Online]. Available: HTTP://www.3gpp.org.
[3] V. Chandrasekhar, J. Andrews, and a. Gatherer, "Femtocell networks: a survey," *IEEE Communications Magazine*, vol. 46, no. 9, pp. 59–67, Sep. 2008.
[4] D. Das and V. Ramaswamy, "Co-channel Femtocell-Macrocell Deployments — Access Control," in *IEEE 70th Vehicular Technology Conference (VTC 2009-Fall)*, 2009, pp. 1 – 6.
[5] P. Xia, V. Chandrasekhar, and J. G. Andrews, "Open vs. Closed Access Femtocells in the Uplink," *IEEE Transactions on Wireless Communications*, vol. 9, no. 12, pp. 3798–3809, Dec. 2010.
[6] T. Elkourdi and O. Simeone, "Outage and Diversity-Multiplexing Trade-off Analysis of Closed and Open-Access Femtocells," in *IEEE Global Telecommunications Conference (GLOBECOM 2010)*, 2010, pp. 1–5.
[7] H. Jo, P. Xia, and J. G. Andrews, "Downlink Femtocell Networks : Open or Closed ?," in *IEEE International Conference on Communications (ICC)*, 2011, pp. 1–5.
[8] H. a. Mahmoud, I. Guvenc, and F. Watanabe, "Performance of Open Access Femtocell Networks with Different Cell-Selection Methods," in *IEEE 71st Vehicular Technology Conference (VTC 2010-Spring)*, 2010, no. 2, pp. 1–5.
[9] G. De Roche, A. Valcarce, and L. David, "Access Control Mechanisms for Femtocells," *Communications*, no. July, pp. 1–7, 2009.
[10] E. S. Mofreh EI- Gendy, "A Study of Access Methods Effect on the Performance of Two-Tier LTE Femtocell Networks," in *28th NATIONAL RADIO SCIENCE CONFERENCE (NRSC 2011)*, 2012, no. Nrsc 2011, pp. 1–8.
[11] L. David, "Access Methods to WiMAX Femtocells : A downlink system-level case study," in *11th IEEE Singapore International Conference on Communication Systems, ICCS 2008.*, 2008,[12] H. A. Mahmoud, "A Comparative Study of Different Deployment Modes for Femtocell Networks," in *IEEE 20th International Symposium on Personal, Indoor and Mobile Radio Communications*, 2009, pp. 1–5.
[13] D. Griffith and N. Golmie, "A probabilistic call admission control algorithm for WLAN in heterogeneous wireless environment," *IEEE Transactions on Wireless Communications*, vol. 8, no. 4, pp. 1672–1676, Apr. 2009.
[14] D. Choi, P. Monajemi, S. Kang, and J. Villasenor, "Dealing with Loud Neighbors : The Benefits and Tradeoffs of Adaptive Femtocell Access," in *IEEE GLOBECOM 2008. IEEE Global Telecommunications Conference*, 2008, pp. 1–5.
[15] P. Xia and J. G. Andrews, "Femtocell Access Control in the TDMA / OFDMA Uplink," in *IEEE Global Telecommunications Conference (GLOBECOM 2010)*, 2010, pp. 1–5.
[16] A. Golaup, M. Mustapha, L. B. Patanapongpibul, and V. Group, "Femtocell Access Control Strategy in UMTS and LTE," *IEEE Communications Magazine*, no. September, pp. 117–123, 2009.
[17] L. Duan, "Capacity Allocation and Pricing Strategies for Wireless Femtocell Services," *Distribution*, pp. 1–32.
[18] I. Demirdogen and P. Alto, "A Simulation Study of Performance Trade-offs in Open Access Femtocell Networks," *Scenario*, pp. 151–156, 2010.

ACKNOWLEDGMENT

This research was sponsored by Sensor Networks & Cellular System Research Center, University of Tabuk, Kingdom of Saudi Arabia.

Sami S. Alwakeel:
Has an M Sc. & Ph.D. Degrees from department of Electrical Engineering, Stanford University, U.S.A. He isa professor at the Department of Computer Engineering, College of Computer & information sciences (CCIS) , King Saud University (KSU) , Riyadh , Kingdom of Saudi Arabia (KSA). He was a founding member and the dean of CCIS. He worked asa consultant to many Saudi government ministries and contributed to the development of many computer colleges and departments in KSA.

Muhammad Ammad-uddin:
Has a M.Sc. Computer Networks in Wireless Networks fromCOMSATS Institute of Information Technology Islamabad Pakistan anda & M.Sc. Of Computer Sciences (MCS)in Software Engineering fromBahria University, Islamabad, Pakistan 2001.
He is CCNA&CCAI Certified and currently is a Lecturer, Department of Computer Science, Tabuk University and a Researcher at Sensor Networks & Cellular System Research center, Tabuk University.Kingdom of Saudi Arabia.