CROSS LAYER EXTENDED PARAMETER CALL ADMISSION CONTROL FOR FUTURE NETWORKS

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Abstract: The Next Generation Network (NGN) is to deliver anything, anytime anywhere with full quality of service (QoS) guarantees. The network designers need to overcome the NGN's challenges namely; heterogeneous wireless access environments, multiple traffic types, flexible bandwidth allocation and cross layer design issues among others. To guarantee quality of service for these NGN's, a call admission control scheme addressing the main challenges of NGN's is presented. This is a cross layer call admission control (CAC) scheme featuring multiple traffic types. The featured model effectively combines call level and packet level call admission control issues. It is based on Code Division Multiple Access (CDMA) air interface which together with Orthogonal Frequency Division Multiple (OFDM) access are the most popular air interface technologies. Traditionally, signal to interference ratio (SIR) has solely been used as the call admission control parameter for CDMA networks. However, the results indicate that due to the nature of the multimedia traffic more parameters need to be incorporated in the call admission control scheme. The presented CAC scheme uses extended user specified QoS parameters of signal to interference ratio (SIR) and delay to accept or reject a call and guarantee a certain call blocking probability QoS metric. The results from the developed model clearly indicate that a CAC algorithm incorporating more parameters outperforms one with less admission control parameters.

Keywords: Call admission control, CDMA, multimedia

1. INTRODUCTION

Next generation network (NGN) design is a major challenge for current telecommunication designers. They are to deliver any traffic anytime anywhere with full quality of service (QoS) guarantees. To realize this, several challenges need to be overcome. These challenges can be grouped majorly into; network challenges and traffic challenges. The NGN's network challenges include those associated with increasing the network capacity, accommodating diverse heterogeneous networks, mobility management and dealing with diverse network protocols, one of them being CDMA. CDMA, a widely applied multiplexing protocol is interference limited. A CDMA network suffers from graceful degradation as the number of users in the system increases; it has a soft capacity [1]. Therefore to guarantee QoS on a CDMA based network an efficient CAC scheme is required. The NGN traffic is very diverse in QoS requirements and presents a challenge to providing a service that satisfies all the users. Multimedia traffic types can be real time or non-real time with different QoS metrics. Real time traffic has stringent delay requirements and can be less stringent on bit error rate (BER) requirement, whereas non real time traffic might not require stringent delay requirements but stringent BER requirements. Traffic may exhibit other properties such as burstiness, correlation and self-similarity [2]. In [3], several traffic classes are proposed; their main distinguishing characteristics are packet error rate (PER) and the delay requirement. The NGN's must support this heterogeneous mix of services with varying QoS metrics. One of the mechanisms to efficiently provide for QoS for the diverse traffic types of the future networks is CAC. A CAC scheme, must consider the key defining traffics QoS metrics like delay and PER for a particular traffic type and ensure that the QoS is maintained. Therefore a single parameter CAC scheme is not sufficient for such diverse traffic.

The QoS metrics for a network are different at different OSI layers. They could be call blocking probability, signal-to-interference ratio (SIR) or bit error probability (BEP) at the higher and physical layers respectively. The QoS metrics can also be at packet level (i.e., queue throughput, packet dropping probability, delay and jitter) or at call level (call dropping probability). To guarantee QoS at different layer, call or packet level, cross-layer optimization is required. Network designers have bridged the OSI structured design and introduced cross layer design [4][5][6]. Cross layer design improves the performance by optimizing the metrics at different levels. Therefore to maintain QoS in future networks, a cross layer CAC with extended QoS metrics is required.

This paper is organized as follows. In Section 2, closely related work done in literature and its critical review is presented. Section 3 presents the system model; cross layer CAC model, network model and the CAC model. Section 4 presents the analytical evaluation of the following; teletraffic model, SIR capacity and delay capacity. The basis of comparing two different CAC

parameters and the performance of the CAC model are discussed in Section 5. Finally the conclusions are presented in Section 6.

2. RELATED WORK

CAC has been an active research area on wireless networks [7]. On a CDMA based wireless network, most CAC algorithms address QoS at one layer and feature only one QoS metric in the admission control algorithm. This tends to be disadvantageous to some traffic types. In [8][9], the physical level QoS metric, SIR, is used as the main parameter for the CAC algorithm. If not directly using SIR, a parameter that translates to SIR is used. In [10], a number based call admission control scheme is developed; however, the equivalent number of users is a function of the SIR. Another parameter used for CAC is power. This is also closely related to the SIR. In [11] only the packet level QoS metric is investigated. Few papers combine both physical level and network level QoS parameters. A CAC scheme which considers both call- and packet-level QoS is required. In [12] packet and call level CAC has been investigated. [13] Extends the call-level and packet-level QoS CAC scheme to adaptive channel allocation. In [6] a cross layer CAC scheme that guarantee both physical layer QoS and network QoS with variable bit rate packet traffic is developed. However, the SIR outage is the major parameter considered even for packet traffic. In the cases reported above, the packet level parameters are not incorporated in the CAC scheme. In [14], a call admission control algorithm for a CDMA system with slotted ALOHA access system is investigated. The CAC algorithm is based on restricting the maximum number of codes allocated to the two traffic types and has a fixed maximum capacity which is not one of the merits of CDMA as it has a soft capacity. The delay is computed in terms of the slots that elapse during the transmission of a packet and is not directly considered in the admission scheme. Delay based call admission control schemes have commonly been used in ATM networks [15]. The admission control is based on the maximum delay bounds. Measurement based call admission control have also been encountered in this networks [16]. These networks are predominantly circuit switched with fixed capacity. CAC algorithms for CDMA networks combining several QoS parameters (delay, SIR) at different levels for future networks have rarely been done in literature. This work develops a CAC scheme to guarantee QoS with the following features:

- Multi criteria CAC scheme with SIR and delay QoS metrics to guarantee a certain call blocking probability. More parameters could further be included in the call admission control scheme albeit for some little complexity.
- A cross layer CAC to maintain both packet level and call level QoS.
- A CAC scheme featuring multiple types of traffic on a variable capacity CDMA link.
- An analytical evaluation of the CAC model capacity featuring CDMA packet scheduling on the wireless link.

3. SYSTEM MODEL

3.1 Cross Layer Model

The CAC model exploits cross layer design to achieve optimal performance. Three different QoS metrics exist at different layers of the protocol stack as follows; call blocking probability at application layer, packet delay at the network layer and SIR at the link layer.

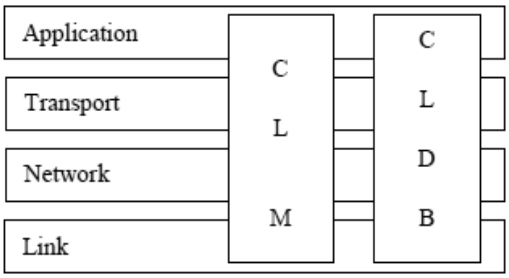

Figure1: The Cross Layer Model

As an adaptation of the models in [4][5], a shared database design is employed. The future CLD design is envisaged to consist of the cross layer manager (CLM) and the cross layer database (CLDB). The CLM is responsible for the interaction between the particular layer and the database. It manages the storage and retrieval of important parameters of a layer and the CLDB. Such a design offers flexibility in terms of expansion and inclusion of other layers and is used in this work. The desired layer QoS metric is stored in the database by the appropriate layer and can be requested by any other layer. The CLD model employs packet delay metric at the network layer, SIR at the link layer to guarantee a particular blocking probability at the application layer.

3.2 Network Model

Consider a wireless mobile network where several mobile stations are being scheduled on the air interface. The multiple access mode used is the CDMA technology. Each mobile station can be of the following traffic types:

- ***Class one***, high priority traffic: Delay and Packet loss sensitive traffic class. This can be the guaranteed service linked to the UMTS conversational traffic type.
- ***Class two***, medium priority traffic: Traffic that can tolerate some delay and packet loss violations. This can be the predictive service linked to UMTS streaming traffic.
- ***Class three***, low priority traffic: The best effort class (BE), the traffic class can be related to the interactive and background traffic classes of the UMTS.

The traffic classes are grouped into the three groups above depending on their desired BER (SNR) and delay. An admitted call generates packets which are policed and then fed in the traffic class's queue. This is shown in Figure 2, where λ_{ik} is the arrival rate of call i of class k and n_k is the number of class k calls. Scheduling on the queues is based on the WFQ for the three traffic classes.

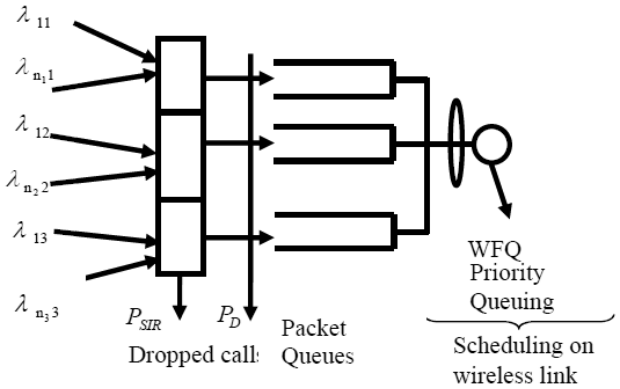

Figure 2: System Model

3.3 Admission Control Algorithm

An arriving call requests admission from the base station. The call admission algorithm is run each time a call arrives and requests capacity and is shown in Figure 3.

```
Call Admission Control Algorithm
An arriving call requests admission from the base station.
  Determine capacity based on SIR ( Eq. 12)
  If there is no capacity
      drop the call
  else
  {
        Determine capacity based on Delay (Eq. 38)
        If there is a violation
            drop the call
        else
           admit the call
  }
```

Figure 3: Call Admission Control Algorithm

The call is either admitted or blocked depending on whether there is capacity based on SIR or delay. The call admission control scheme is based on the two QoS parameters of SIR and delay. To admit a new call i of class k the following conditions must be satisfied. The guaranteed QoS (delay bound $d_{req,ik}$, PEB or $(E_b/N_o)_{req,ik}$), for the particular call should be provided and the QoS of the existing calls should not be severely affected by admitting the call. The teletraffic model to evaluate the CAC scheme and the analysis of call admission control capacity is done in the next section.

4. MODEL ANALYTICAL EVALUATION

4.1 Teletraffic analytical evaluation

A network with three traffic classes in the system is considered. The system can thus be analysed as markov chain with state $S = \{n_1, n_2, n_3\}$, where n_k is the number of class k calls communicating with the base station. This is a multidimensional markov chain where the effect of the time-varying capacity of the link and the delay bound are incorporated into the arrival process. The different admission priorities are incorporated in the admission control algorithms. The traffic characteristics used in the evaluation of the model are as follows:

- A homogeneous system in statistical equilibrium is assumed and therefore only one cell is analyzed.
- A new call of class k, $\{k = 1,...N\}$ arrive at the cell according to a Poisson process with rate λ_k
- The service time of a class k call is exponentially distributed with mean μ_k
- The sources are modelled as ON-OFF with exponentially distributed ON and OFF durations of call i of class k as v_{ik}, w_{ik} respectively.
- The traffic generated by user i of class k when it is ON is characterized by a token bucket filter with parameters (r_{ik}, b_{ik}), class parameter (r_k, b_k).
- The user specifies the QoS parameters as the delay bound $d_{req,ik}$ and the desired BER which can be translated into the desired SIR threshold $(E_b/N_o)_{req,ik}$

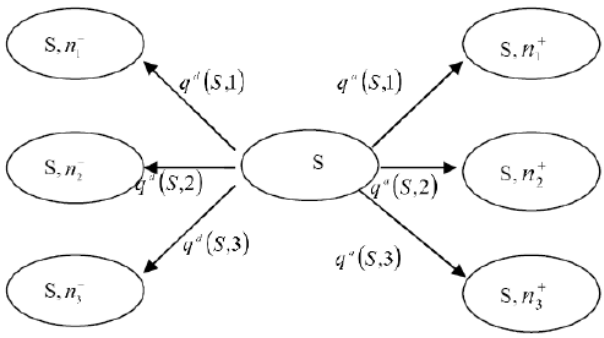

Figure 4: State Transitions diagram

For the system, let $S = \{n_1, n_2, n_3\}$ be the current state of the system, (S, n_k^+) and (S, n_k^-) the state after the arrival and departure of a class k call respectively. The state transistions $q^a(S,k)$ and $q^d(S,k)$ represent the arrival and departure of a class k call in state S. The state transition diagram is shown in Figure 4. The transition rates are given by

$$q^a(S,k) = P^a(S,k)\lambda_k \quad (1)$$

and

$$q^d(S,k) = \mu_k \tag{2}$$

where $P^a(S,k)$ is the probability of admitting a class k call in state S. Let $\pi(s)$ be the stationary probability of state s. The state balance equations must satisy the following equations:

$$\pi(s)\sum_k \sum_i q^a(S,k) + q^d(S,k) = \pi(s^+)\sum_k \sum_i q^d(S^+,k) + \pi(s^-)\sum_k \sum_i q^a(S^-,k) \tag{3}$$

and

$$\sum_{s\in S} \pi(s) = 1 \tag{4}$$

The call blocking probability of a class k call, ψ_k is given by

$$\psi_k = \sum_{s\in S}\{1 - P^a(S,k)\}\pi_s \tag{5}$$

where $P^a(S,k) = p_A^D . p_A^S$ and the values of the SIR and delay capacity, p_A^S and p_A^D are as derived in equations (12) and (38) respectively in the next section.

4.2 CAC capacity based on interference

The received signal to noise ratio $(E_b/N_o)_{ik}$ of user i $\{i = 1,2,..M_k\}$ of class k $\{k = 1,...N\}$ is given by

$$(E_b/N_o)_{ik} = \frac{G_{ik}h_{ik}p_{ik}}{(1+f)\sum_k\sum_{j\neq i} h_{jk}\alpha_{jk}p_{ik} + \eta_o W}, \tag{6}$$

where G_{ik} the processing gain, h_{ik} the path gain, p_{ik} the transmitted power, α_{jk} the source activity factor, η_o the noise factor, W the bandwidth, f the ratio of the external $I_{ext,k}$ to internal $I_{\text{int},k}$ interference. For the users to meet their target SIR, equation (6), under a minimum power, the following equation should be satisfied [17][18]

$$\sum_{k=1}^{M}\sum_{i=1}^{n_k} \alpha_{ik} g_{ik} \le \frac{1-\Delta_{ik}}{(1+f)}, \tag{7}$$

where g_{ik} the power index and Δ_{ik} the power constraint. They are given as

$$g_{ik} = \frac{(E_b/N_o)_{req,ik}}{((E_b/N_o)_{req,ik} + G_{ik})}, \tag{8}$$

$$\Delta_{ik} = \frac{\eta_o W}{\min_i(p_{ik}h_{ik}/g_{ik})}. \tag{9}$$

From equation (7), introducing a capacity restraining constant φ that can be used to limit capacity for different traffic classes we have

$$Z = (C(t) + \Delta(t) + f(t)C(t)) \le \varphi, \tag{10}$$

where:

$$C(t) = \sum_k \sum_i \alpha_{ik}(t) g_{ik}. \tag{11}$$

Due to the CDMA soft capacity and wireless nature, Z, is a random variable whose mean and variance can be calculated. The probability of accepting a call based on SIR, p_A^s, is the given by the following equation

$$P_A^S = P(Z \le \varphi), 0 < \varphi \le 1. \tag{12}$$

If equation (12) is satisfied we conclude that there is capacity based on SIR. The mean and variances of Z are calculated next.

Considering that the shadowing and received powers of differently-located mobiles are mutually independent, and $\alpha_{ik}(t)$ is a Bernoulli distributed random variable with parameter α, $f(t), C(t)$ and $\Delta(t)$ are independent [19]. The mean and variance of $C(t)$ are derived as:

$$E[C(t)] = E\left[\sum_k \sum_i \alpha_{ik}(t) g_{ik}\right] = \sum_k \sum_i g_{ik}\alpha, \tag{13}$$

$$Var[C(t)] = \sum_k \sum_i (g_{ik})^2 \alpha(1-\alpha) \tag{14}$$

Assuming that the intracell interference is independent of the intercell interference [20]. The mean and variance of $f(t)$ is derived as:

$$E[f(t)] = E[I_{ext}]E\left[\frac{1}{I_{\text{int}}}\right] \tag{15}$$

$$Var[f(t)] = (Var[I_{ext}] + (E[I_{ext}])^2)E\left[\frac{1}{(I_{\text{int}})^2}\right] - (E[f(t)])^2. \tag{16}$$

Following the standard derivations [23], the expectation of intercell interferes for a mobile station l of class k located at a distance r_{lk}^m from its cell site, r_{lk}^o from the cell site of the desired user in the region R_o with received S_k is given by,

$$E[I_{ext}] = \sum_{k=1}^{N}\sum_{l=1}^{M_k} C_{m,other}, \tag{17}$$

where;

$$C_{m,other} = S_k \alpha \iint_{R_o} \left(\frac{r_{lk}^m}{r_{lk}^o}\right)^4 v\left(\frac{r_{lk}^m}{r_{lk}^o}\right) dr_{lk}^o dr_{lk}^m \tag{18}$$

$$v\left(\frac{r_{lk}^m}{r_{lk}^o}\right) = \left(e^{(\sigma \ln 10/10)^2}\right) \bullet \left\{1 - Q\left[\frac{40}{\sqrt{2\sigma^2}}\log\left(\frac{r_{lk}^m}{r_{lk}^o}\right) - \sqrt{2\sigma^2}\,\frac{\ln 10}{10}\right]\right\}. \tag{19}$$

The variance of the intercell interference is given by,

$$Var[I_{ext}] = \sum_k \sum_l C_{v,\text{inter}} \tag{20}$$

where

$$C_{v,\text{inter}} = \iint_{R_o} (S_k)^2 \left(\frac{r_{lk}^m}{r_{lk}^o}\right)^8 \left[\alpha g\left(\frac{r_{lk}^m}{r_{lk}^o}\right) - \alpha^2 v^2\left(\frac{r_{lk}^m}{r_{lk}^o}\right)\right] dr_{lk}^o dr_{lk}^m \tag{21}$$

$$g\left(\frac{r_m}{r_o}\right)=e^{(\chi\ln 10/5)^2}\left\{1-Q\left[\frac{40}{\sqrt{2\sigma^2}}\log\left(\frac{r_o}{r_m}\right)-\sqrt{2\sigma^2}\left(\frac{\ln 10}{5}\right)\right]\right\} \quad (22)$$

$$Q(x)=\frac{1}{\sqrt{2\pi}}\int_x^{\infty}e^{-\frac{y^2}{2}}dy \quad (23)$$

For intercell interference, the Jensens inequality bound [21] is used to calculate the expectations as follows

$$E\left[\frac{1}{I_{\text{int}}}\right]\geq\frac{1}{\left[\sum_k\sum_{j\neq i}C_{m,\text{int}ra}\right]} \quad (24)$$

where $C_{m,\text{int}ra}=S_k\alpha e^{(\beta\sigma)^2/2}e^{\beta m}$ and $\beta=\ln(10)/10$. Similarly

$$E\left[\frac{1}{(I_{\text{int}})^2}\right]\geq\left(E\left[\frac{1}{(I_{\text{int}})}\right]\right)^2 \quad (25)$$

From equation (9), the variance and expectation of Δ_{ik} is given by

$$\mathrm{E}[\Delta]=\eta_0\mathrm{W}\sum_{j=1}^{N}E[\mathrm{X_i}]E[\Phi_i], \quad (26)$$

where

$$\Phi_i=\begin{cases}1, & X_I>X_J.....X_K\\ 0 & \text{otherwise}\end{cases}. \quad (27)$$

The expectation $E[X_i]$ can be easily evaluated given that the users are uniformly distributed throughout the cell. From the definition of Φ_i in equation (27), with the help of equation (28) below the expectation $E[\Phi_i]$ is easily derived

$$P(X_i>X_k)==1-Q\left(\frac{10}{\sqrt{2\sigma^2}}\log\left(\frac{1}{y_{ik}}\left(\frac{r_k}{r_i}\right)^u\right)\right) \quad (28)$$

This is based on the assumption that ζ_i and ζ_k are independent, thus $\zeta_i-\zeta_k$ is a gaussian random variable with zero mean and variance $2\sigma^2$. A similar derivation is obtained for $E[\Delta^2]$ and thus the variance.

4.3 CAC capacity Based on delay

The packet capacity is dependent on the scheduling on the wireless link. Unlike other networks CDMA systems have introduced soft capacity. The scheduling capacity employed in calculating the delay bounds cannot be fixed. The capacity of a CDMA system is power or interference limited. The resources of a CDMA system exhibit the two dimensional nature [22], power and interference. The capacity can be derived in terms of the chip rate R_c and a power element $1-\Delta$ and is given by

$$C=R_c(1-\Delta) \quad (29)$$

For utilizing the capacity weighted fair queuing discipline (WFQ) is used for the different classes. The capacities of the traffic class one C_{μ_1} and traffic class two $C_{\mu 2}$ are

$$C_{\mu_1}=\frac{n_1\phi_1}{n_1\phi_1+\phi_2}\frac{R_c(1-\Delta)}{G_k g_k}=C_1(1-\Delta) \quad (30)$$

$$C_{\mu_2}=\frac{\phi_2}{n_1\phi_1+\phi_2}\frac{R_c(1-\Delta)}{G_P g_P}=C_2(1-\Delta) \quad (31)$$

where ϕ_1 and ϕ_2 are the overall weighting factors of traffic Class 1 and traffic Class 2 respectively, n_1 is the number of Class 1 traffic users and G_k is the class processing gain. Class 3 queue can be treated like a low priority Class 2 queue.

Assuming the term Δ is a log normally distributed random variable with PDF $P_\Delta(x)$ and CDF $F_\Delta(x)$. Its mean and variance have been calculated in the previous section. The pdf's of $P_{\mu_1}(x)$, and $P_{\mu_2}(x)$, are derived from equations (30) and (31) as

$$P_{\mu_1}(x)=\frac{1}{|C_1|}P_\Delta\left(1-\frac{x}{C_1}\right) \quad (32)$$

and

$$P_{\mu_2}(x)=\frac{1}{|C_2|}P_\Delta\left(1-\frac{x}{C_2}\right). \quad (33)$$

The traffic of class k, token limited by (r_k, $\mathrm{b_k}$) is arranged in queues depending on the delay. Consider admitting user i of class k with token parameters r_{ik} and b_{ik}. The delay for the Class 1 traffic queue is given by [16]

$$D_{\max,j1}=\frac{\sum_{s=1}^{n_1}b_s+b_{ik}}{C_{\mu_1}}=\frac{C_3}{C_{\mu_1}}. \quad (34)$$

Utilizing the pdf's of equation (32), the delay probability is evaluated as

$$P_{D_{\max,j1}}(d)=\frac{|C_3|}{d^2}P_{\mu_1}\left(\frac{C_3}{d}\right) \quad (35)$$

Similarly, the delay bound for the predictive class (Class 2) queue is given by

$$D_{\max,j2}=\frac{\sum_{s=1}^{n_2}b_s}{C-C_{\mu_1}-\sum_{s=1}^{n_2-1}r_s}=\frac{\sum_{s=1}^{n_2}b_s}{C_{\mu_2}-\sum_{s=1}^{n_2-1}r_s}=\frac{C_4}{C_{\mu_2}-C_5}, \quad (36)$$

together with equation (33) the delay probability is given as

$$P_{D_{\max,12}}(d)=\frac{|C_4|}{d^2}P_{\mu_2}\left(\frac{C_4}{d}+C_5\right) \quad (37)$$

The specified user delay bound $d_{req,ik}$ translates into a class delay bound d_{bk}. Let the delay in the system for class k be d_{qk} and the delay distribution for class k be $P_{D_{\max,k}}(d)$. A user will be admitted with a probability P_A^D given by

$$P_A^D=\prod_{k=1}^{M}P_{D_{\max,k}}(d_{bk}<d_{qk}) \quad (38)$$

If by admitting the incoming user equation (38) holds then there is capacity based on delay.

Table 1: Simulation parameters

Parameter	Value
Call duration	200 s
Mean on time	0.5s
Mean off time	1s
Packet rate	20pkts/s
Token rate (aggregate)	100tokens/s
Bucket depth	10 tokens
Processing gain	128
Chip rate	1.25MHZ
AWGN	10^{-18}
Max Power	1 W

5. DISCUSSION AND RESULTS

The analytical evaluation is used to determine the performance of the CAC algorithms. The analytical model is validated by a simulation model based on a developed C++ discrete event simulator [24]. The call arrivals were assumed to be Poisson distributed and the service times exponentially distributed. There was traffic shaping and a CDMA link used. The chosen parameters are as indicated in Table 1.

5.1 Call admission schemes comparison

The CAC parameters of SIR and delay have no relationship with each other. The grounds for comparison of the different CAC parameters must be established. In this respect admission control based on the two parameters is independently investigated.

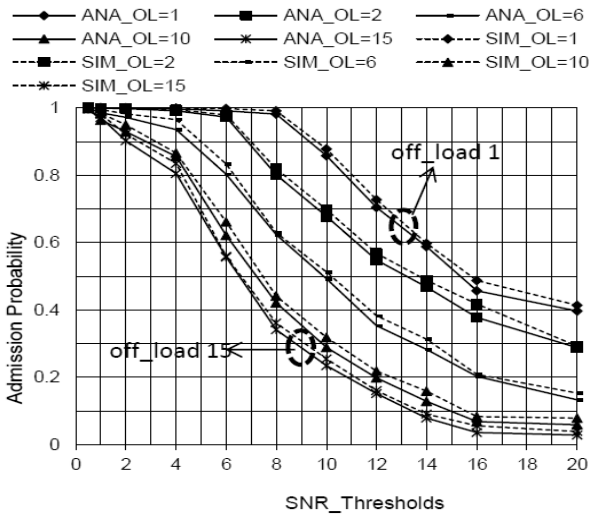

Figure 5: Performance of SIR CAC vs. SIR Threshold

The results of Figure 5 shows the performance of the SIR based call admission control scheme. The results clearly indicate that the admission probability reduces with an increase in the required SIR threshold. This is as expected since the lower the target SNR the higher the probability of admitting the call. This happens for all different offered loads, however, the admission probabilities reduce as the offered load increases. From the results, the analytical results are closely mirrored by the simulation results.

The results of Figure 6 shows the performance of the delay based call admission control model. The results clearly indicate that the admission probability increases with an increase in the required delay threshold. This is as expected since the higher the target delay the higher the probability of admitting the call. This happens for all different offered loads, however, the admission probabilities reduce as the offered load increases. From the results, the analytical results are closely mirrored by the simulation results.

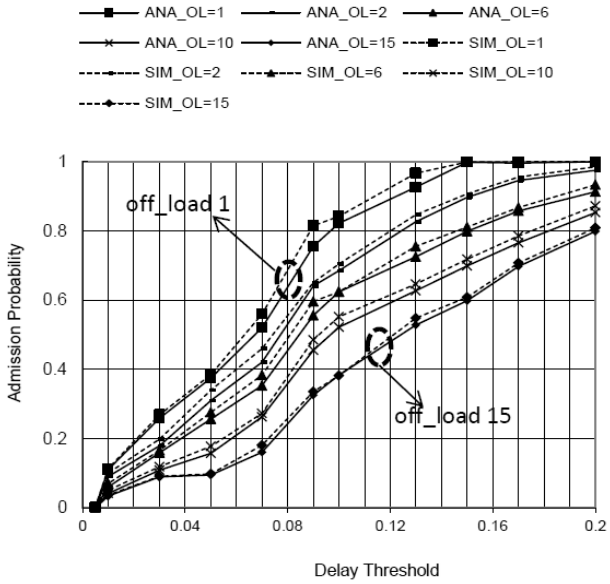

Figure 6: Performance of Delay CAC vs. delay Threshold

Table 2 shows values extrapolated from the SIR based admission control (Figure 5) and Delay based admission control (Figure 6). The table tries to relate the SIR threshold that achieves the same system performance, in terms of admission probability, as the delay threshold. This is done at different offered loads and forms the basis of comparing the call admission control schemes with different performance metrics. For evaluating the performance of the CAC, sets one and two of Table 2 are chosen for comparison purposes.

Table 2: SIR and Delay thresholds comparison

Admission probability	ρ_1		ρ_2		ρ_6		ρ_{10}		ρ_{15}	
	SIR_T	D_T	SIR_T	D_T	SIR_T	D_T	SIR_T	D_T	SIR_T	D_T
1	0.5	0.15	0.5	0.4	0.5	0.5	0.5	0.6	0.5	0.7
0.8 SET1	**11**	**0.09**	**8**	**0.12**	**6**	**0.15**	**4.5**	**0.18**	**4**	**0.2**
0.6	14	0.075	11.5	0.085	8.5	0.095	6.5	0.12	5.7	0.15
0.4 SET2	**20**	**0.054**	**16**	**0.064**	**11.5**	**0.073**	**8.5**	**0.085**	**7.5**	**0.1**
0.2	40	0.02	30	0.03	16	0.04	12.5	0.055	10	0.075

5.2 Performance of Admission Control Algorithms

The results of the system performance in terms of the call admission probability versus the offered load are shown in Figure 7. The results are done for the three call admission control schemes. The parameters are selected as SET 1 and SET 2 of Table 2. The SIR and delay thresholds are selected to achieve a target blocking probability and are applied on the same network. Both the SIR and Delay based CAC schemes achieve the desired admission probabilities as indicated in the table. The Combined CAC algorithm achieves relatively higher admission probabilities for the same parameters. This clearly indicates that using one parameter, underestimates the true network blocking probabilities due to all the network factors. In this case, the delay CAC algorithm is less stringent than both the combined and SIR based CAC algorithm.

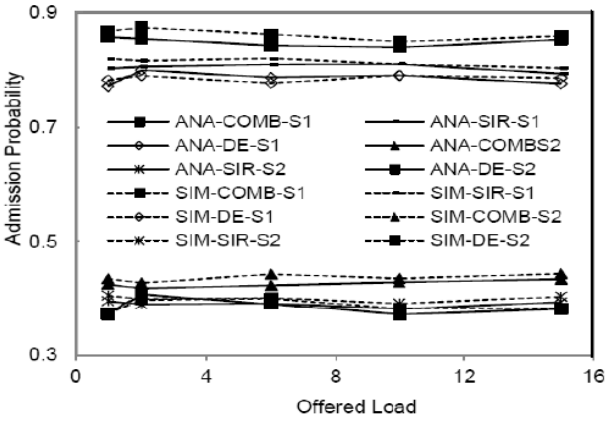

Figure 7 Performances of the CAC Algorithms

Figure 8 shows the same system performance in terms of the outage probability for the call admission control algorithms. Outage is measured as the ratio of calls that do not satisfy QoS parameter. The results indicate that the outage probabilities are slightly lower for all the admission algorithms. However, the combined CAC model achieves the lowest outage probabilities and thus asserting its superiority. The outage also increases as the offered load increases.

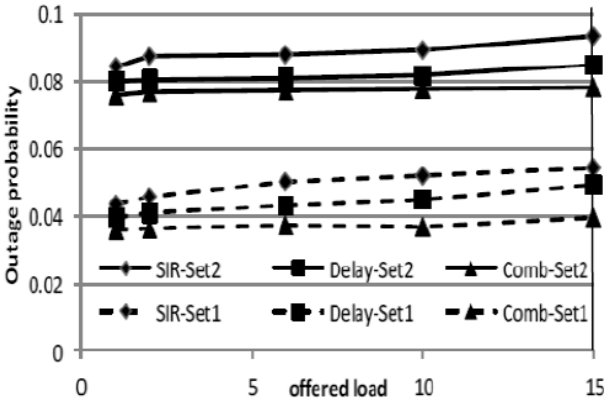

Figure 8 Performances of the CAC Algorithms

6 CONCLUSIONS

This work has developed a model for call admission control on next generation networks with two parameters, delay and signal to interference ratio. Further a test bed for the comparison of two independent CAC parameters is developed. The results from the developed model clearly indicate that a CAC algorithm incorporating more parameters outperforms one with less admission control parameters. The analytical results are validated by simulation results. Generally we can conclude that more parameters need to be incorporated at admission since the traffic types are widespread and have different admission requirements.

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