International Journal of the Physical Sciences Vol. 6(36), pp. 8120 - 8129, 30 December, 2011
Available online at http://www.academicjournals.org/IJPS
DOI: 10.5897/IJPS11.720
ISSN 1992 - 1950 ©2011 Academic Journals

Full Length Research Paper

Linear probability based admission control policy for video on demand system

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Accepted 22 November, 2011

In this paper, we propose a dynamic admission control policy for distributed video on demand system, based on linear probability function. The probability of accepting a video request is calculated by using a liner mathematical formula. Quality of service (QoS) is granted by restricting the requests on the basis of popularity of request and availability of resources. The popular video request will get better chance to be accepted. The distinction of this paper from the others is dynamic admission control policy instead of static and threshold. The evaluation of proposed system is done by simulation model, number of rejected requests and total generated revenue is calculated for performance measurement, and it is observed that proposed admission control policy not only improves the performance of all the request classes but also improves a lot the overall system.

Key words: Dynamic probability, admission control, blocking probability, quality of service, video on demand, multimedia communication, internet protocol television (IPTV).

INTRODUCTION

Admission control is a key component for quality of service (QoS) delivery in video on demand (VOD) system because it determines which request is accepted and which is not and how network resources are utilized. Admission control in video on demand system has become an important area of interest for most network researchers. Many studies like Chang and Zakhor (1994), Mundur et al. (2004), Qazzaz et al. (2003), and Young et al. (1998) describes that End-to-end Quality of Service can be achieved by call admission control.

In cellular and wireless network, Dynamic Admission control is also very important for the allocation and management of bandwidth / radio resources for different types of call (New or Handover) and for different class of service (voice, video and data) and many researches are conducted in this regard; such research includes Kasigwa et al. (2005), Elek et al. (2000) and Samir and Jongbok, (2002). As explained by Kim and Hwangjun (2010), QoS of video streaming over Worldwide Interoperability for microwave access (WiMAX) can indemnify by implementing techniques, packet switching and call admission control. QoS for WiMax is maintained by estimating the future need of bandwidth and prediction of bandwidth is done by control parameters and periodic updates. Uniqueness of this study is use of combination of packet switching and call admission control for guarantying QoS for video streaming in WiMAX. The only drawback of this study is control parameters and periodic updates are overhead. Class based admission control is discussed by Mundur et al., (2005) and Al-Wakeel et al. (2010) proposed combination of class based and shared resource call admission control for guarantying QoS for video on demand system. According to Sami and Ammad-uddin (2010), video server is partitioned equal to the number of requesting class plus shared area. If incoming request is not possible to accept in corresponding partition then this request will be admitted in shred area with some probability. If no probability or no space in shared area then this request is rejected. The short coming of this paper is fixed probability is used which is not sufficient to fulfill the dynamic and varying nature of VOD system. Lin (1998) described two admission control policies (static and probabilistic) and also proposed required minimal buffer. Statistic on available data is used for both the

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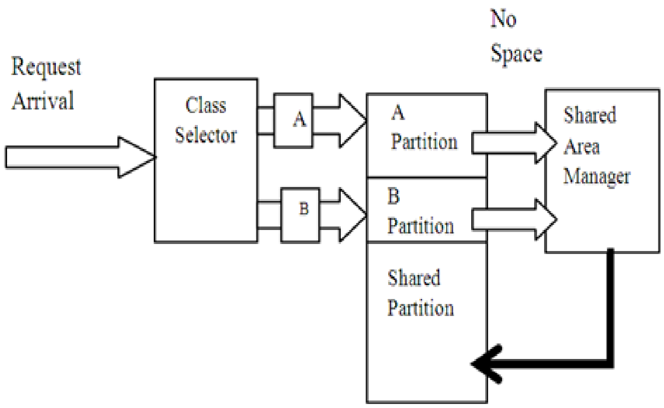

Figure 1. Proposed LPACP system.

admission control schemes.

According to Thiago et al. (2010) VOD system is divided into two regions uncorrelated and correlated. Call admission control (CAC) is done separately for both regions. Picture type dependent arrival rate histogram (PD-AH) and Moarkov fluid (MMF) models are used respectively for both regions for call admission control.

Latre et al. (2009) said that (PCN) pre-congestion notification is used for call admission control. In PCN model, nodes are classified into three categories; ingress, egress and interior. When traffic load acceded the threshold value at interior node it calculates the congestion level and marks the packets. The marked packets are aggregated at egress node and congestion-Level-Estimate (CLE) is calculated by weighted moving average. This CLE value is communicated to ingress node. All allowing/blocking decisions are done at ingress node.

Shamsul et al. (2005) proposed sami-distributed admission control (SD-AC) for existing telephone network; the whole architecture is divide into three levels central control (CC), Local control (LC) and (MSF) Media server farm. MSF provides the resources for video streaming LC tracks the available resources of MSF, all LC are centrally connected with CC. if any request cannot be admitted by LC due to shortage of resources then the request will be forwarded to CC. CC checks the available resources of all the LC's, if CC will find any LC having required resources then this LC will be assigned for this request otherwise rejection message is send to the user.

Little attention has been paid to the dynamic aspect of admission control in VOD system. The static admission control methods operate well in the management of simple VOD networks, however, the static admission control methods cannot cope with dynamic changes of incoming traffic and network topology. The proposed linear probability based admission control policy for video on demand system (LPACP) targeted the following important areas:

1. The system resources should be used efficiently such that Maximum of the requests should be admitted because the more the admitted requests more the revenue.
2. Most of the resources are used all the time and always have a capacity to admit the request of most popular programs because popular (expansive) class request generates more revenue as compared to less popular.
3. The probability of a request to be admitted or rejected is dynamic depending on the popularity of class of request, arrival rate of that class, availability of resources and work load of server.

As shown in Figure 1, the proposed system total capacity of VOD server (ports) is partitioned equal to the number of classes plus shared area. When a request arrives, class selector decides the class of service that request belongs to, and then class selector sends the incoming request to its corresponding partition. If concern partition has capacity, request is accepted, otherwise request will is not be rejected straight forward and handed over to shared area manager (SAM), SAM will calculate the dynamic probability of that request to access the shared area, if shared area has capacity and that request has probability then this request will be accepted and resources will be given from shared area.

PROPOSED ADMISSION CONTROL POLICY

The proposed system is different from other works it extends the admission control based on (a) statistic CAC as described by Biersack and Thiesse (1996) , Kim et al. (2001), Vin et al. (1994) and Zimmerman and Fu (2003), and (b) threshold CAC as described by Chen and Chen (1996), to dynamic probability based admission control (LPACP).

In the proposed system, VOD server capacity is partitioned as; $C1, C2, - - - CN, + CS$. C is class of request, N is total priority classes and CS is a shared area. Request arrives with rate of $\lambda 1$, $\lambda 2$,---, $\lambda \nu$. Suppose request arrives for a video belongs to class I, the proposed system will admit the incoming request if $Ci > Oi$, Ci is capacity of concern class and Oi is occupancy of that class at that time. If there is no capacity ($Ci <= Oi$) in the particular class then this request will be handed over to shared area manager (SAM). SAM will admit this request in shared area with a dynamic probability Pi. If there is no probability / no capacity in shared area then call will be rejected.

The probability of acceptance of any request in shared area is dynamic, depending upon the remaining server capacity and total arrival of that class at time ***T***. The dynamic probability of request acceptance, of any class will not go above 100% and below its minimum level. The minimum level for each class is also dynamic, depends upon the percentage (%) of arrival of that class.

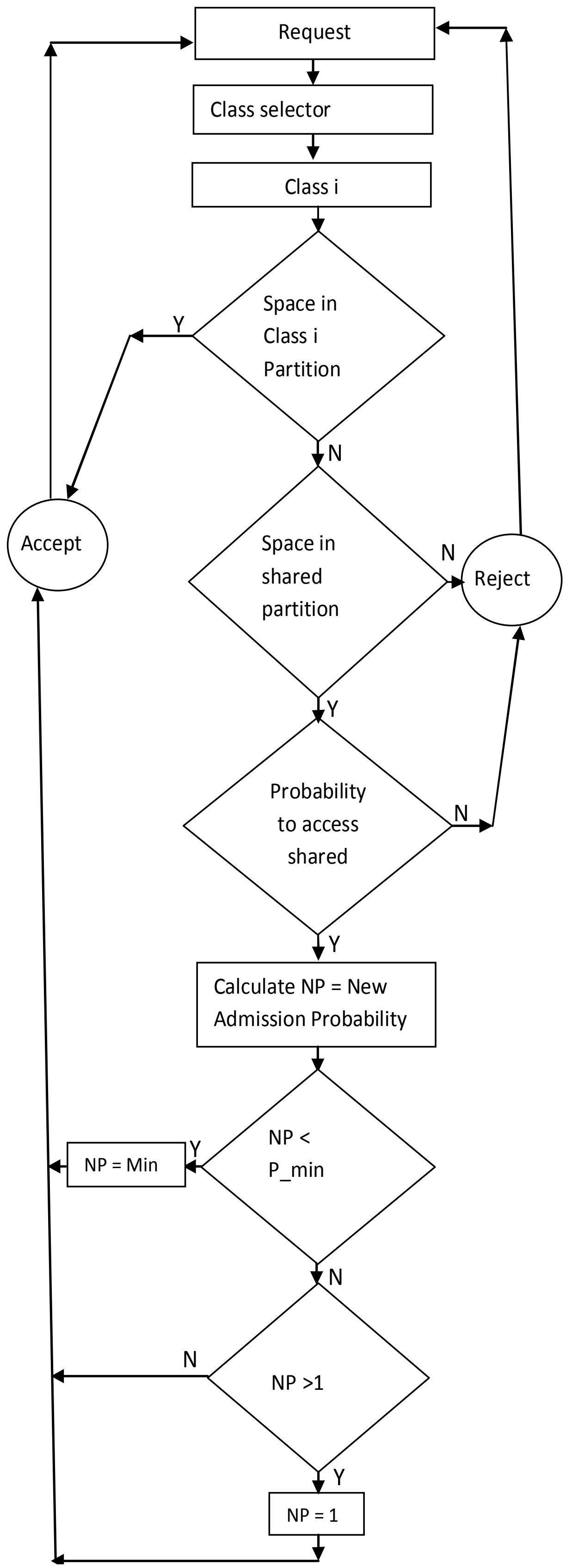

Figure 2. LPACP system flow chart.

Linear dynamic probability

If a request of class ***i*** arrive and its particular partition ***i*** is full then this request will handed over to SAM to decide whether it can be admitted in shared area or not.

Initially, the SAM will set the acceptance probability to minimum level for all classes to access the shared area, with the passing of time the probability of each class will be increased in linear fashion depending upon its arrival rate and remaining capacity of server resources.

Whenever a request of class ***i*** will be accepted in shared area, its probability to access shared area next time will be increased by linear function shown as Equation 1 (Increasing probability):

$$Pi = p_{i-1} + \partial \left(\frac{shared\ free\ ports}{Shared\ total\ ports} + \frac{Arrival\ of\ class\ i}{total\ Arrival} \right) \quad (1)$$

P_i is new probability for class i to access the shared area next time and P_{i-1} is old probability of that class and Ə is normalizing factor.

On the other hand, probability of all other classes will be decreased by linear function (Equation 2):

$$Pj = p_{j-1} - \partial \left(\frac{shared\ Busy\ ports}{Shared\ total\ ports} + \frac{Arrival\ of\ other\ classes}{total\ Arrival} \right) \quad (2)$$

The minimum probability of each class to access the shared area depends upon the percentage of total arrival of that class at time ***T***. The algorithm of proposed system is given bellow and flowchart is shown in figure 2.

Input parameters:

K classes o < I < k
λ= Arrival rate of incoming request
Pi = Admission probability
PA = Initial Probability for class A
PB = Initial Probability for class B
P_ min = Minimum Probability for class A
P_ min = Minimum Probability for class A

Algorithm

1. User requests, arrival with rate λ
2. Decide what is the class clam of that arrival
3. Get class **i**
4. If space in *Ci* then accept this request
5. Else if probability to access shared area then Accept this request
6. Else no probability reject this request
7. Calculate new probabilities for each class:

Table 1. Variable arrival rate and random movie time.

Parameter	Value
Partition size (ports)	Class A 25%, class B 25%, Shared 50%
Movie time (min)	Random (90, 120)
Arrival rate (requests per minute) = Variable	4, 6, 8, - - - - ,16; λA = 70% λB = 30%
Total simulation time	24 h

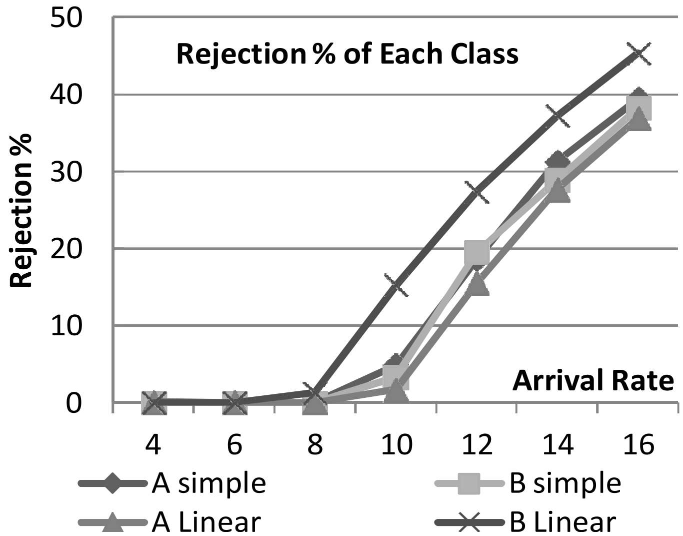

Figure 3. Variable arrival rate and random movie time, rejection % of each class.

a. ***Pi*** = equation (1)
b. If ***Pi >1 Pi = 1***
c. Also calculate ***Pj*** where ***j ≠ i***
d. ***Pj*** = equation (2)
e. If ***Pj < P_min*** Pj = p_min
8. Go to step -1

The results taken by simulation of this algorithm are used to Calculate Revenue generated.
NA= No of admitted requests of class A
NB = No of admitted requests of class
***Br*A** = Price of class A movies
rB = Price of class B movies
Revenue = (NA. rA) + (NB. rB)
Compare the total Revenue of the system with dynamic probability and with out probability

SIMULATION

The proposed system is simulated with variation of different input parameters (arrival rate of class *A*, arrival rate of class *B*, movie duration, partition size) then results are compared with simple no probability case. Simulation is conducted in OMNet ++ and different simulation runs and their results are given as follows.

Simulation Run 1 (variable arrival rate and random movie time)

Proposed admission control policy is tested against increasing load, in terms of increasing the total number of incoming requests from 4 requests per minutes to 16 requests per minutes; the duration of requested movies by each request is also random and can vary from 90 to 120 min. and all other parameters are constant and given in Table 1.

It is clearly shown in Figure 3 that rejection percentage of popular class is reduced a lot in proposed LPACP policy. The comparison of total rejection percentage of both the system (linear probability function and without any probability) is shown in Figure 4 and it is observed that almost 12% improvement is achieved in linear case. Accumulated revenue graph is shown in Figure 5 and it is clear that almost 12 to 15% more revenue can be generated by using the proposed admission control policy.

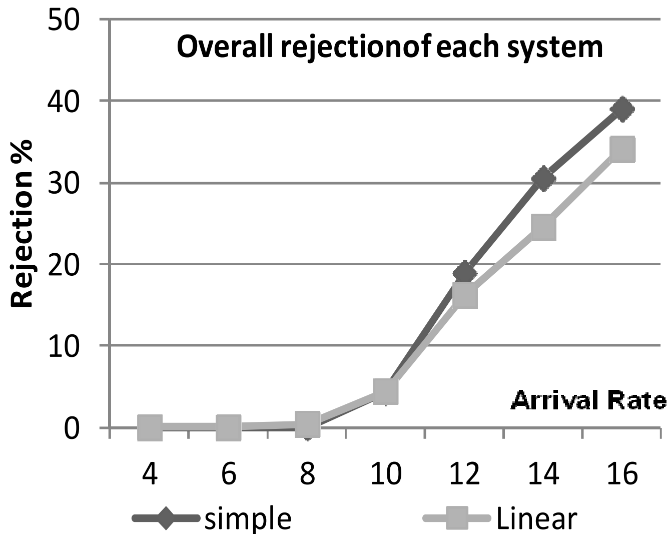

Figure 4. Variable arrival rate and random movie time, rejection of overall system.

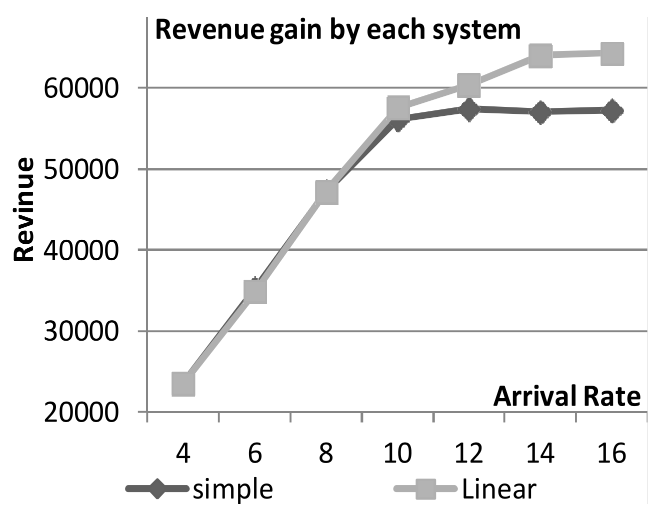

Figure 5. Variable arrival rate and random movie time, revenue generated.

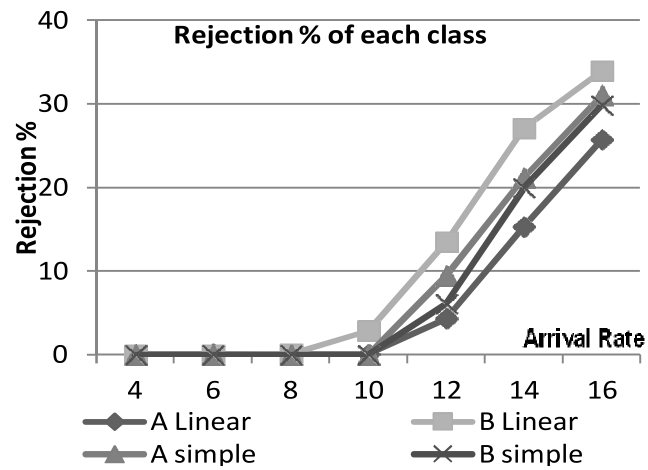

Figure 6. Variable arrival rate and fix movie time, rejection % of each class.

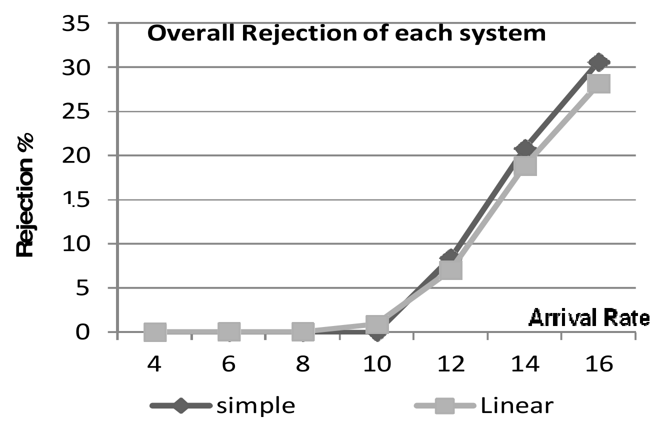

Figure 7. Variable arrival rate and fix movie time, overall system rejection.

Table 1. Variable arrival rate and fix movie time.

Parameter	Value
Partition size (ports)	Class A 25%, class B 25%, shared 50%
Movie time (min)	90
Arrival rate (requests per minute)	4, 6, 8,- - - ,16; λA = 70%, λB = 30%
Total simulation time	24 h

Simulation Run 2 (Variable arrival rate and fix movie time)

Run 2 is similar to Run 1. Proposed system is tested against the increasing load. The only difference is the duration of requested movie is fixed to 90 min for all requests. All input parameters are given in Table 2 and results are shown in Figure 6 to 8.

Simulation Run 3 (Variable movie time and fix arrival rate)

In this run, proposed system is tested against effect of increasing the movie time (duration) from 50 to 120 min. Total load (incoming arrival request) is constant. Input parameters are shown in Table 3 and results are given in

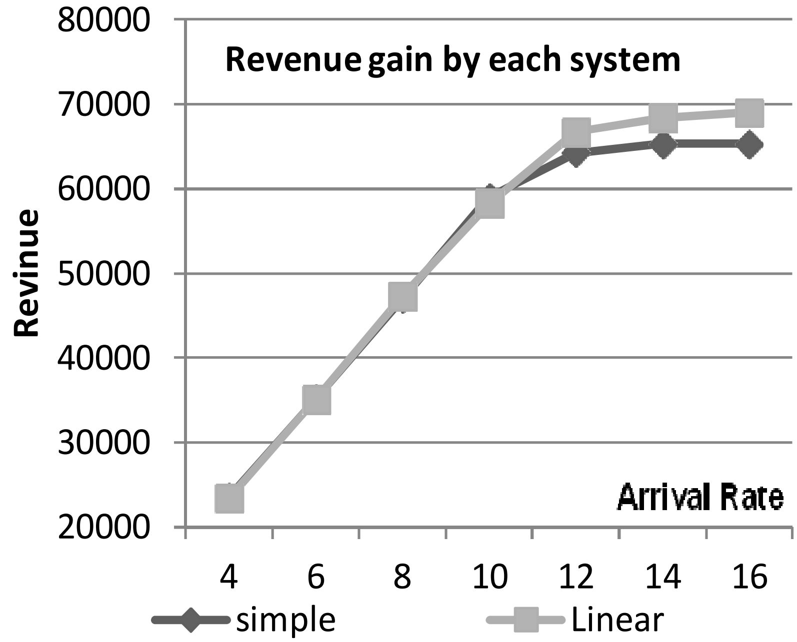

Figure 8. Variable arrival rate and fix movie time, revenue generated.

Table 3. Variable movie time.

Parameter	Value
Partition size (ports)	class A 25%, class B 25%, shared 50%
Movie time (per min)	50, 60, - - - , 120
Arrival rate (requests per min)	12 λA= 70, λB = 30%
Total simulation time	24 hours

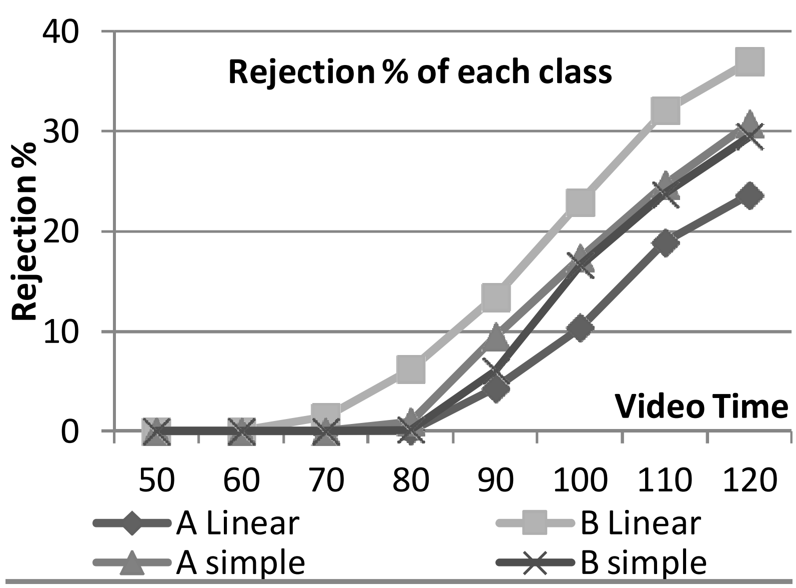

Figure 9. Variable movie time, rejection of each class.

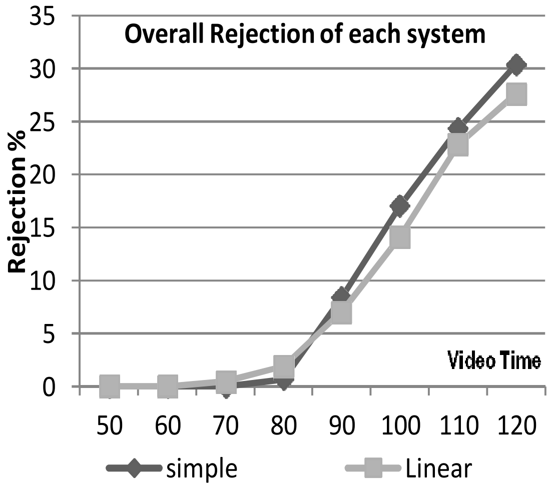

Figure 10. Variable movie time, overall system rejection.

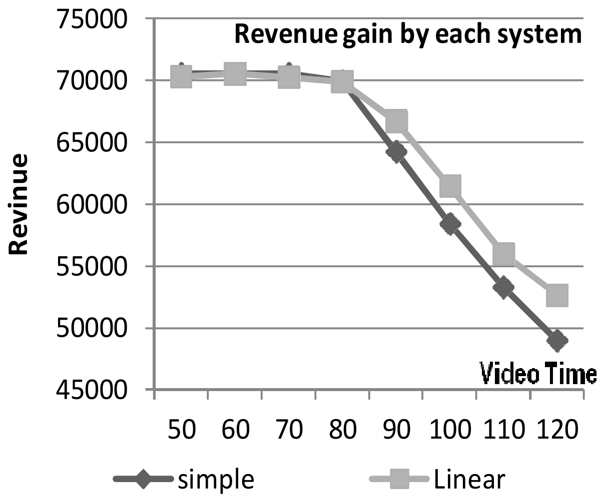

Figure 11. Variable movie time, revenue generated.

Figures 9 to 11. Improvement in terms of rejection percentage of calls and revenue generated can be seen easily in all results.

Table 2. Variable partition size.

Parameter	Value
Shared parts %	100, 90, 80,- - - - , 0
Movie time (min)	90
Arrival rate (requests per minute)	12λA% = 70, λB =30%
Total simulation time	24 h

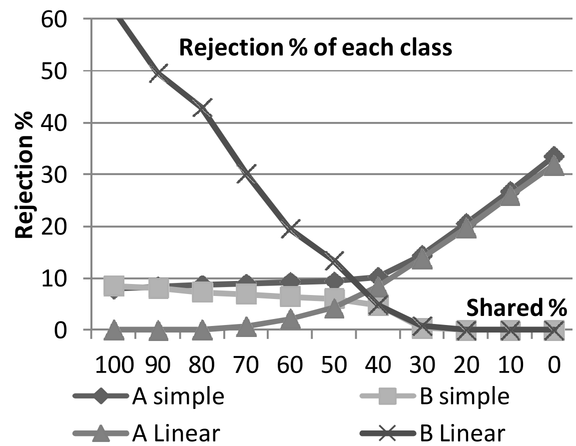

Figure 12. Variable partition size, rejection of each class.

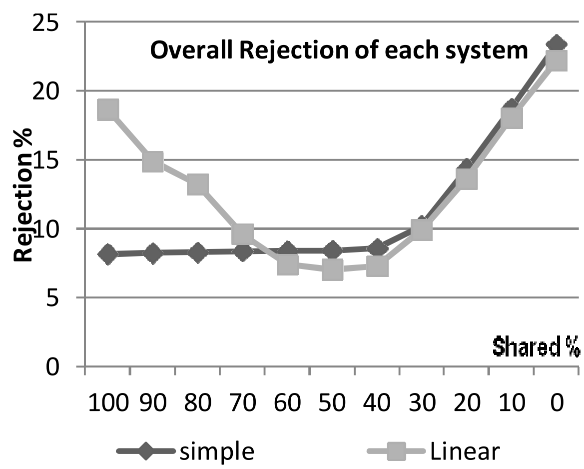

Figure 13. Variable partition size, overall system rejection.

Simulation Run 4 (fix arrival rate fix movie time and variable partition size)

In this simulation run, performance of proposed system is tested against the varying of partition size. When shared area is 0% means 50% ports are assigned to Class *A* (popular class) and 50% for Class *B* (unpopular class). When shard area is 100%, it means no partition is reserved for Class *A* and Class *B*; all resources (ports/ bandwidth) are shared. Other parameters are shown in Table 4 and simulation result of this simulation run is shown in Figures 12 to 14. It is observed from Graph 13 that maximum call acceptance is achieved when shared partition is 40 to 60% of the total available resources. Graph 14 shows that maximum revenue can be generated by setting the shared area up-to 60% of the total resources. It is conclude form this simulation run that

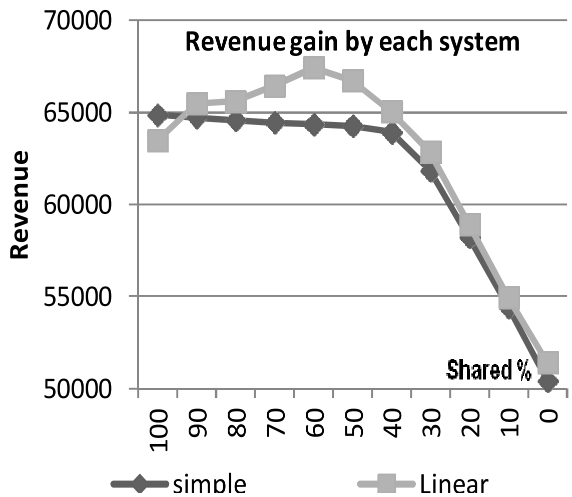

Figure 14. Variable partition size, revenue generated.

Table 5. Variable arrival rate of class A.

Parameter	Value
Partition size (ports)	Class A 25%, Class B 25%, Shared 50%
Movie time (min)	90
Arrival rate λA (requests per minute)	4, 6, 8, - -- , 16
Arrival rate λB (requests per minute)	6
Total simulation time	24 h

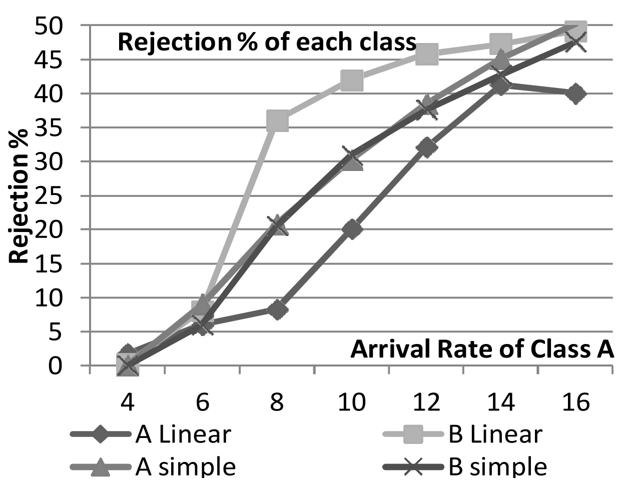

Figure 15. Variable arrival rate of class A, rejection of each class.

the proposed CAC policy will gives the best results when shared part is in between 50 and 60% of the total resources.

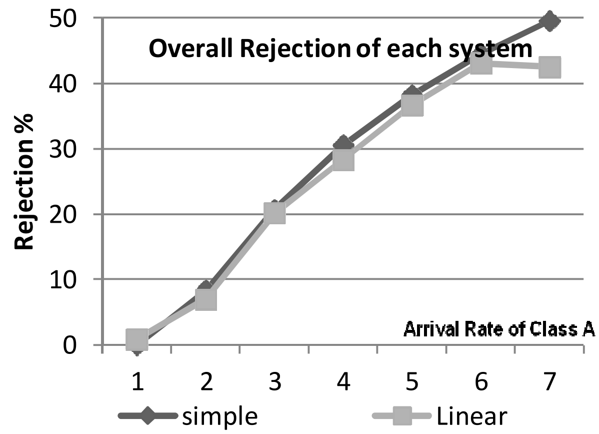

Figure 16. Variable arrival rates of class A, overall system rejection.

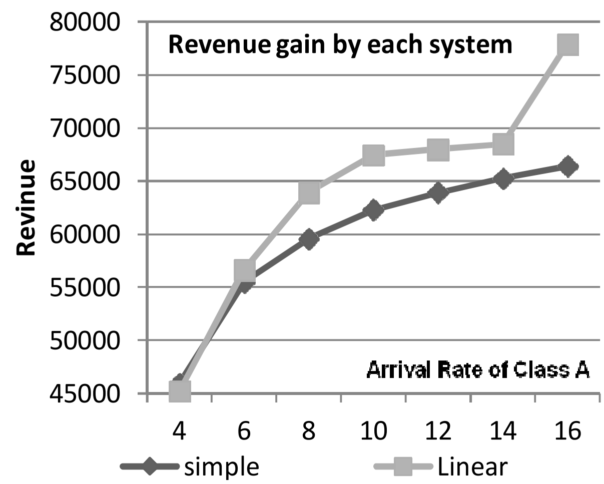

Figure 17. Variable arrival rate of class A, revenue generated.

Simulation Run 5 (variable arrival rate of class a and fix movie time)

In this simulation run, proposed system is tested against increase in load of only high priority class (class A) and all other parameters are constant and given in Table 5 and results are shown in Figures 15 to 17. As per expectations, results are impressive.

Simulation Run 6 (variable arrival rate of class b and fix movie time)

In this simulation run, proposed system is tested against increase in load of only low priority class (class *B*) only, all other parameters are constant and given in Table 6 and simulation results are shown in Figures 18 to 20, as

Table 6. Variable arrival rate of class b.

Parameter	Value
Partition size (ports)	Class A 25%, Class B 25%, Shared 50%
Movie time (min)	90
Arrival rate λA (requests per minute)	12
Arrival rate λB (requests per minute)	4, 6, 8, - - - , 16
Total simulation time	24 hours

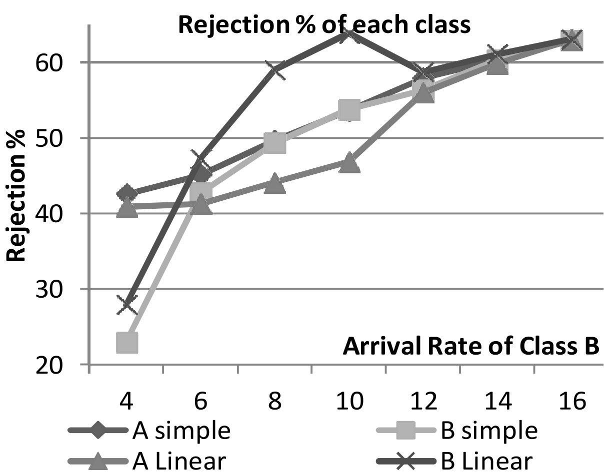

Figure 18. Variable arrival rate of class b, rejection % of each class.

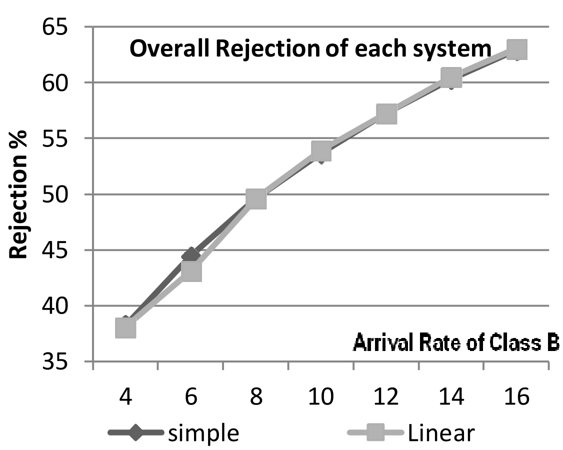

Figure 19. Variable arrival rate of class B, overall rejection of system.

per expectations performance of our proposed system is out-classes.

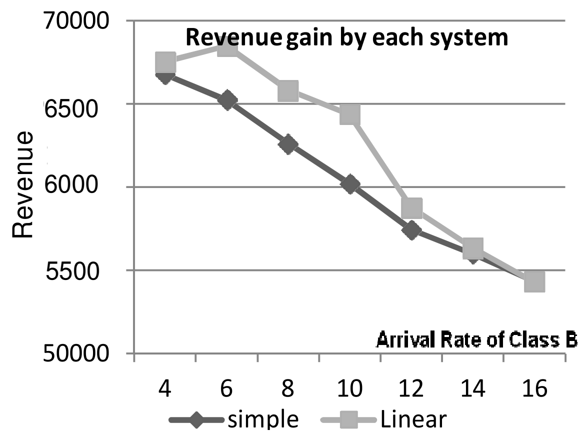

Figure 20. Arrival rate of class B, revenue generated.

RESULT ANALYSIS

Linear probability dynamic admission control system was simulated and compared with no probability admission control. Both the systems are tested with variations of different parameters like total arrival rate, movie duration and partition size. It is analyzed from Figures 3, 6, 9, 12, 15 and 18 that in all the cases mention previously, rejection percentage of both the classes (popular, unpopular) is reduced a lot in proposed linear probability dynamic admission control policy. It is also observed from Figure 4, 7, 10, 13, 16 and 19 that total rejection percentage of over-all system is improved about 12 to 15% in proposed system. As shown in Figures 5, 8, 11, 14, 17 and 20 that 12 to 15% more revenue can be generated by using our admission control policy.

The allocation of resources (bandwidth and ports) for different class of service is most critical decision, and performance of proposed system heavily depends upon this parameter. Operator can manage the available resources in better way by considering the different traffic patterns, QoS requirement, User preferences, and service provider's policies. As per analysis of results shown in Figures 12 to 14, it is recommendation for operator that our proposed system will gives maximum performance if shared area is 40 to 60% of the total available resources.

Conclusion

In this paper, a novel (LPACP) Dynamic Probability based Admission Control policy for VOD system has been designed and developed for improvement in QoS of VOD system. The proposed dynamic admission control policy distributes the server resources fairly among the different classes of incoming requests popular and expansive class request will always have priority over unpopular and cheaper class request to generate more revenue. Simulation results show that linear dynamic admission control policy performs better than no probability admission control policy. Linear admission control policy is the best choice for the allocation of server resources (ports, bandwidth) among different classes of traffic in video on demand system such that maximum revenue can be generated. By using proposed system, not only rejection percentage of high priority class improve it also improves the rejection of other class and rejection of over all system. Finally by using linear dynamic admission control policy, the over all revenue will increase significantly.

ACKNOWLEDGEMENT

This work is supported by the Research Center of College of Computer and Information Sciences in King Saud University. The authors are grateful for this support.

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